SMC Standard SMC-S-011
31 July 2015

Supersedes:
SMC-S-011 (2012)

Air Force Space Command

SPACE AND MISSILE SYSTEMS CENTER STANDARD

PARTS, MATERIALS, AND PROCESSES CONTROL PROGRAM FOR EXPENDABLE LAUNCH VEHICLES

FOREWORD

1. This standard defines the Government's requirements and expectations for contractor performance in defense system acquisitions and technology developments.

2. This SMC standard comprises the text of The Aerospace Corporation report number TR-RS-2015-00011, entitled *Parts, Materials and Processes Control Program for Expendable Launch Vehicles*. Community review was solicited in The Aerospace Corporation report number TOR-2015-00519, entitled *Working Draft Review: Proposed Updates to Launch Vehicle Parts, Materials, and Processes Standard*, dated 16 December 2014. This update contains the following major changes from the prior version:

- Rewrote as a performance-based standard
- Updated appendices to address materials and processes, printed wiring boards, and de-rating (including other-than-military temperature range parts)

3. Beneficial comments (recommendations, changes, additions, deletions, etc.) and any pertinent data that may be of use in improving this standard should be forwarded to the following addressee using the Standardization Document Improvement Proposal appearing at the end of this document or by letter:

Division Chief, SMC/ENE
SPACE AND MISSILE SYSTEMS CENTER
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245

4. This standard has been approved for use on all Space and Missile Systems Center/Air Force Program Executive Office - Space development, acquisition, and sustainment contracts.

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Contents

1. Scope

1.1 Purpose

This document establishes the requirements for the preparation, implementation, and operation of a Parts, Materials, and Processes (PMP) Control Program for use during the design, development, and production of mission critical components, as defined in Section 3 herein, on expendable launch vehicles (ELVs). The implementation of these requirements is intended to:

1. Assure integrated management of the selection, application, procurement, control, and standardization of parts, materials, and processes (PMP)

2. Improve the reliability of program PMP to reduce PMP failures at all levels of assembly and test

3. Reduce program lifecycle cost

4. Improve procurement and test of small quantities of parts and materials that meet system requirements

1.2 Application

This document is intended for use in acquisition contracts for launch vehicle programs. The document should be cited as a compliance document in the contract schedule or the statement of work. The document defines the minimum acceptable requirements for ELV applications and as such shall not be tailored except where allowed by the contract or as specified herein. The requirements are intended to be used to coordinate at the program level the selection, application, management, and procurement of PMP throughout the design, development, and production cycles of an acquisition.

2. Applicable Documents

2.1 Compliance Documents

Unless otherwise specified, the following specifications, standards, and handbooks of the revision in effect at the time of invitation to bid to the government acquisition activity form part of this document to the extent specified herein. Documents not identified by revision or date shall be the latest issue in effect.

2.1.1 Military Specifications

MIL-PRF-20	Capacitors, Fixed, Ceramic Dielectric (Temperature Compensating) Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-27	Transformers and Inductors (Audio, Power, and High Power Pulse), General Specification for
MIL-PRF-123	Capacitors, Fixed, Ceramic Dielectric (Temperature Stable and General Purpose), High Reliability, General Specification for
MIL-PRF-3098	Crystal Units, Quartz, General Specification for
MIL-DTL-3655	Connectors, Plug and Receptacle, Electrical (Coaxial Series Twin), and Associated Fittings, General Specification for
MIL-DTL-5015	Connectors, Electrical, Circular Threaded, AN Type, General Specification for
MIL-PRF-6106	Relays, Electromagnetic (Including Established Reliability (ER) Types), General Specification for
MIL-PRF-15305	Coils, Fixed and Variable, Radio Frequency, General Specification for
MIL-PRF-19500	Semiconductor Devices, General Specification for
MIL-PRF-19978	Capacitors, Fixed, Plastic (or Paper-plastic) Dielectric, (Hermetically Sealed in Metal, Ceramic or Glass Cases) Established and Non Established Reliability, General Specification for
MIL-PRF-21038	Transformers, Pulse, Low Power, General Specification for
MIL-PRF-23269	Capacitors, Fixed, Glass Dielectric, Established Reliability, General Specification for
MIL-PRF-23419	Fuse, Instrument Type, General Specification for
MIL-PRF-23648	Resistors, Thermal (Thermistor) Insulated, General Specification for
MIL-DTL-24308	Connectors, Electrical, Rectangular, Miniature Polarized Shell, Rack and Panel, General Specification for

MIL-PRF-24236	Switches, Thermostatic, (Metallic and Bimetallic), General Specification for
MIL-DTL-26482	Connectors, Electrical, (Circular, Miniature, Quick Disconnect, Environment Resisting) Receptacles and Plugs, General Specification for
MIL-PRF-28861	Filters and Capacitors, Radio Frequency/Electromagnetic Interference Suppression, General Specification for
MIl-PRF-31032	Printed Circuit Board/Printed Wiring Board, General Specification for
MIL-PRF-38534	Hybrid Microcircuits, General Specification for
MIL-PRF-38535	Integrated Circuits (Microcircuits) Manufacturing, General Specification for
MIL-DTL-38999	Connector, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breach Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-PRF-39003	Capacitors, Fixed, Electrolytic (Solid Electrolyte), Tantalum, Established Reliability, General Specification for
MIL-PRF-39005	Resistors, Fixed, Wirewound (Accurate), Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39006	Capacitors, Fixed Electrolytic (Nonsolid Electrolyte), Tantalum, Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39007	Resistor, Fixed, Wirewound (Power Type), Established Reliability and Non-Established Reliability, and Space Level, General Specification for
MIL-PRF-39008	Resistor Fixed, Composition (Insulated), Established Reliability, General Specification for
MIL-PRF-39009	Resistors, Fixed, Wirewound (Power Type, Chassis Mounted), Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39010	Coils, Fixed, Radio Frequency, Molded, Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39012	Connectors, Coaxial, Radio Frequency, General Specification for
MIL-PRF-39014	Capacitors, Fixed, Ceramic Dielectric (General Purpose), Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39015	Resistors, Variable, Wirewound (Lead Screw Actuated), Established Reliability and Non-Established Reliability, General Specification for

MIL-PRF-39016	Relays, Electromagnetic, Established Reliability and Non-Established Reliability, General Specification For
MIL-PRF-39017	Resistors, Fixed Film (Insulated), Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-39035	Resistor, Variable, Non-wirewound (Adjustment Type), Established Reliability, General Specification for
MIL-I-46058	Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
MIL-PRF-50884	Printed Wiring, Flexible and Rigid Flex
MIL-PRF-55182	Resistors, Fixed, Film, Established Reliability and Non-Established Reliability, General Specification for
MIL-DTL-55302	Connectors, Printed Circuit Subassembly and Accessories
MIL-PRF-55310	Oscillators, Crystal Controlled, General Specification for
MIL-PRF-55342	Resistors, Fixed, Film, Chip, Established Reliability and Non-Established Reliability, General Specification for
MIL-PRF-55365	Capacitors, Fixed, Electrolytic (Tantalum) Chip, Established Reliability, Non-Established Reliability and High Reliability
MIL-PRF-55681	Capacitors, Chip, Multiple Layer, Fixed, Encapsulated, Ceramic Dielectric, Established Reliability and Non-Established Reliability, General Specification for
MIL-DTL-81381	Wire, Electric, Polyimide - Insulated, Copper or Copper Alloy
MIL-PRF-83401	Resistor Networks, Fixed, Film, General Specification for
MIL-PRF-83421	Capacitors, Fixed, Metallized, Plastic Film Dielectric, (DC and AC), Hermetically Sealed in Metal Cases, Established Reliability
MIL-DTL-83723	Connectors, Electrical, (Circular, Environment Resisting), Receptacles and Plugs, General Specification for
MIL-PRF-83733	Connectors, Electrical, Miniature, Rectangular Type, Rack to Panel, Environment Resisting, 200°C Total Continuous Operating Temperature, General Specification for
MIL-PRF-87164	Capacitors, Fixed, Mica Dielectric, High Reliability, General Specification for
MIL-PRF-87217	Capacitors, Fixed, Supermetallized Plastic Film Dielectric, Direct Current for Low Energy, High Impedance Applications, Hermetically Sealed in Metal Cases, Established Reliability, General Specification for

2.1.2 Military Standards

MIL-STD-202	Department of Defense Test Method Standard for Electronic and Electrical Component Parts
MIL-STD-403	Preparation for and Installation of Rivets and Screws, Rocket, Missile, and Airframe structures
MIL-STD-810	Environmental Test Methods and Engineering Guidelines
MIL-STD-866	Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 psig or Over
MIL-STD-889	Dissimilar Metals
MIL-STD-981	Design, Manufacturing, and Quality Standards for Custom Electromagnetic Devices for Space Applications
MIL-STD-1580	Destructive Physical Analysis for Space Quality Parts
MIL-STD-2073	DOD Material Procedures for Development and Application of Packaging Requirements

2.1.3 NASA Publications

NASA-STD-5019	NASA Technical Specification: Fracture Control Requirement for Spaceflight Hardware
NASA SP-8063	Lubrication, Friction and Wear
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.3	Soldered Electrical Connections
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring

2.1.4 Industry Specifications

IPC-2152	Standard for Determining Current-Carrying Capacity In Printed Board Design
IPC 2221	Generic Standard on Printed Board Design
IPC 2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC 2223	Sectional Design Standard for Flexible Printed Boards
IPC 6012	Qualification and Performance Specification for Rigid Printed Boards

IPC 6013	Qualification and Performance Specification for Flexible Printed Boards
J-STD-001 (Space Addendum)	Requirements for Soldered Electrical and Electronic Assemblies
J-STD-005	Requirements for Soldering Pastes
J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications
JESD-625	Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices
ANSI/ESD S20.20	Protection of Electrical and Electronic Parts, Assemblies and Equipment
SAE-AS1933	Age Controlled for Hose Containing Age Sensitive Elastomeric Materials
SAE-AS22759	Wire, Electrical, Fluoropolymer-Insulated Copper or Copper Alloy
SAE-ARP5316	Storage of Elastomers, Seals and Seal Assemblies, which Include an Elastomer Element prior to Hardware Assembly
SAE-AMS-2175	Castings, Classification and Inspection of
SAE-AMS 2759	Heat Treatment of Steel Parts, General Requirements
SAE-AMS 2774	Heat Treatment, Wrought Nickel Alloy and Cobalt Alloy Parts
SAE-AMS-H-6875	Heat Treatment of Steel Raw Materials
ANSI/IPC-DW-425	Design and End Product Requirements for Discrete Wiring Boards
ANSI- NEMA-MW1000	Wire, Magnet, Electrical, General Specification for
ASTM-B-661	Standard Practice for Heat Treatment of Magnesium Alloys
ASTM-E-595	Total Mass Loss and Collected Volatile Condensable Materials From Outgassing in a Vacuum Environment, Standard Test Method for
AWS-C3.4	Torch Brazing, Specification for
AWS-C3.5	Induction Brazing, Specification for
AWS-C3.6	Furnace Brazing, Specification for
AWS-C3.7	Aluminum Brazing, Specification for
AWS-C3.9	Resistance Brazing, Specification for

AIAA-S-110	Space Systems Structures, Structural Components, and Structural Assemblies
AIAA-S-080	Standard for Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components
AIAA-S-081A	Standard for Space Systems – Composite Overlap Pressure Vessels
AWS D17.2/ 17.2M: 2007	Specification for Resistance Welding for Aerospace Applications
SAE-AMS-A-21180	Aluminum-Alloy Castings, High Strength
SAE-AMS-C-7438	Core Material, Aluminum, For Sandwich Construction
SAE-AMS-H-6875	Heat Treatment of Steels (Aircraft Practice), Process for
SAE-AMS-H-7199	Heat Treatment of Wrought Copper-Beryllium Alloys, Process for (Copper Alloys: Numbers C17000, C17200, C17300, C17500, And C17510) (Stabilized Type)
SAE-AMS-H-81200	Heat Treat of Titanium and Titanium Alloys
SAE-AMS-STD-1595	Qualification of Aircraft, Missile, and Aerospace Fusion Welders
SAE-AMS-STD-2154	Inspection, Ultrasonic, Wrought Metals, Process for
SAE-AMS 2728	Heat Treatment of Wrought Copper Beryllium Alloy Parts
SAE-AMS 2762	Carburizing Carbon and Low-Alloy Steel Parts
SAE-AMS 2768	Heat Treatment of Magnesium Alloy Castings
SAE-AMS 2770	Heat Treatment of Wrought Aluminum Alloy Parts
SAE-AMS 2771	Heat Treatment of Aluminum Alloy Castings
SAE-AMS 2772	Heat Treatment of Aluminum Alloy Raw Materials
SAE-AMS 2773	Heat Treatment Cast Nickel Alloy and Cobalt Alloy Parts
SAE-AMS 5343	Steel, Corrosion Resistant, Investment Castings, 16Cr - 4.1Ni - 0.28Cb (Nb) - 3.2Cu, Homogenization, Solution, and Precipitation Heat Treated (H1000), 150 ksi (1034 MPa) Tensile Strength (17-4)
SAE-AMS-C-7438	Core Material, Aluminum, for Sandwich Construction
SAE-AMS-T-9047	Titanium and Titanium Alloy Bars (Rolled or Forged) and Re-forging Stock, Aircraft Quality
SAE-AMS-A-21180	Aluminum Alloy Castings, High Strength

SAE-AMS-STD-401	Sandwich Construction and Core Materials, General Test Method

2.1.5 Space and Missile Systems Center Standards

SMC-S-003	Quality Assurance for Space and Launch Vehicles Originally published as TR-RS-2015-00003
SMC-S-013	Reliability Program for Space Systems Originally published as TOR-2007(8583)-6889
SMC-S-016	Test Requirements for Launch, Upper-Stage, and Space Vehicles Originally published as TR-RS-2014-00016

2.2 Guidance Documents

2.2.1 Military Specifications

MIL-STD-2219 (Canceled)	Fusion Welding for Aerospace Application
MIL-STD 1346 (Canceled)	Relays, Selection and Application of
MIL-A-46106	Adhesive-Sealants, Silicone, RTV, One Component
MIL-A-46146	Adhesives – Sealants, Silicone, RTV, Noncorrosive (for Use with Sensitive Metals and Equipment)
MIL-PRF-55110	Printed Wiring Boards, General Specification for
MIL-PRF-83536	Relays, Electromagnetics, Established Reliability, General Requirements for
MIL-PRF-14409	Capacitors, Variable (Piston Type, Tubular Trimmer), General Specification for

2.2.2 Military Standards

MIL-STD-401	General Test Methods, Sandwich Construction and Core Materials

2.2.3 Military Handbooks

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-17	Polymer Matrix Composites, Volume 1, Guidelines
MIL-HDBK-83377	Adhesive Bonding (Structural) for Aerospace and Other Systems, Requirements for

(Copies of specifications, standards, handbooks, drawings, and publications required by contractors in connection with specified acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

2.2.4 NASA Publications

MSFC-SPEC-3029	Guidelines for the Selection of Metallic Materials for Stress Corrosion Cracking Resistance in Sodium Chloride Environments
NASA-STD-6012	Corrosion Protection for Space Flight Hardwarer
MSFC-SPEC-3679	Process Specification-Welding Aerospace Flight Hardware
MSFC-STD-557	Threaded Fasteners, Titanium Alloys, Usage Criteria for Launch Vehicle and Spacecraft Applications

(Application for copies should be addressed to: Marshall Space Flight Center, Document Repository (AS24D), Huntsville, AL 35812)

2.3 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document shall take precedence. Nothing in this document, however, shall supersede applicable laws and regulations.

3. Definitions and Acronyms

3.1 Definitions

3.1.1 Alternate PMP

An alternate PMP is of the same form, fit, and function with equal to or better quality, reliability, and survivability as the baseline PMP and can be used without restrictions.

3.1.2 Acquisition Activity

The acquisition activity is the government, contractor, or subcontractor acquiring the equipment, system, subsystem, part, or material for which this standard is being contractually applied.

3.1.3 Catastrophic Electronic Part Failures

A catastrophic failure is any part that is open or shorted or nonfunctional (this is typically any parametric measurement which exceeds its specified limits by 100% or more or parametric degradation that prevents the part from performing its intended function). The Parts Materials and Processes Control Authority (PMPCA) may define a more stringent requirement based upon the device application.

3.1.4 Categories of Components

3.1.4.1 Category I

Any component that is defined as both mission critical and single string, or mission critical and a single point failure. Any component that is part of the flight termination system is also considered Category I and subject to these requirements unless otherwise specified.

3.1.4.2 Category II

Any component that is defined as mission critical and redundant excluding flight termination system components.

3.1.5 Component

A component is an assembly of two or more parts which in their assembled form combine to perform a vehicle-level function. A component is replaceable as a unit and, through proper disassembly, is subject to repair and rework. Examples of assemblies classified as components are actuators, valves, batteries, electrical harnesses, or individual electronic boxes.

3.1.6 Contracting Officer

A contracting officer is a person with the authority to enter into, administer, or terminate contracts and make related determinations and findings. The term includes authorized representatives of the contracting officer acting within the limits of their authority as delegated by the contracting officer.

3.1.7 Critical Parameter

A critical parameter is a feature (electrical or mechanical) that is required in a specific application to be within the specified limits in order for the design to perform as intended.

3.1.8 Derating

Derating of a part is the intentional reduction of applied stress, with respect to its rated operational limit for the purpose of providing a margin between the applied stress under worst case design applications and the demonstrated limit of the part's capabilities.

3.1.9 Discrete Wiring Boards

Discrete wiring boards are boards that utilize discrete wires to interconnect termination areas on or within flexible or rigid materials that may contain common on-board foil electrical conductors.

3.1.10 Electronic Component

An electronic component provides electrical, radio frequency, or optical signals to or receives electrical, radio frequency or optical signals from other components on the ELV or on the ground.

3.1.11 Electronic Parts

For the purposes of this document, electronic parts are all electronic, electromechanical, electro-optical and electrical (EEEE) parts including connectors (connector shell, insert, and contacts).

3.1.12 Established Reliability

Established reliability (ER) codes are assigned to certain military specification Qualified Parts listed on the Qualified Parts List (QPL) based upon continuous sample testing of each lot date code. Test results are expressed as either an Exponential or a Weibull failure rate level.

3.1.13 Expendable Launch Vehicle (ELV)

An expendable launch vehicle (ELV) is a vehicle designed to be used only once to carry a payload into space and their components are not recovered for reuse.

3.1.14 Expendable Launch Vehicle (ELV) Quality PMP Baseline

The ELV Quality PMP Baseline represents items that are in Appendices A, C, D, E, and L:

a. Readily available

b. Documented on government specifications (MIL-Specs or Standards), high reliability DLA drawings, or DOD adopted industry specifications

c. Have demonstrated heritage of reliable performance in launch vehicle programs

d. May come with designators indicating space grade (Classes V, S, K for actives, and Class S/T-level for passives), Weibull grade or established reliability failure rates.

e. Manufactured and tested on government certified/qualified lines with periodic Defense Logistics Agency/Land and Maritime (DLA/LM) audits

3.1.15 Failure Mode Effects and Criticality Analysis (FMECA)

Analysis of a system starting at the lowest hardware /software level and systematically working to higher indenture levels determining the elements in which failures can occur (failure modes) and the effects of each potential failure on the system element in which it occurs, as well as affecting other system elements. The analysis shall include a study of the relative mission significance or criticality of all potential failure modes.

3.1.16 Lot of Parts

A lot of parts is defined as a group of homogeneous parts of the same design and construction revision, part number; manufactured in the same facility and tested using the same production processes, the same tools and machinery, material, same manufacturing and quality controls; same baseline document revisions.

3.1.17 Lot Date Code

A lot date code is typically a four-digit designator that represents the year and week the part or material is manufactured. The first two numbers in the code are the last two digits of the year, while the last two numbers are the calendar week of that year. NOTE: For non-MIL parts Lot Date Code scheme may vary based on commodity and manufacturer.

3.1.18 Lot Rejection

Lot rejection is the failure of a lot to meet one or more of the acceptance criteria specified.

3.1.19 Manufacturing Baseline

The manufacturing baseline is an engineering drawing(s), normally in the form of a flow chart, of the sequence of manufacturing operations necessary to produce a specific part, including all process specifications and revisions, lot travelers, and the construction analysis.

3.1.20 Material

Material is a metallic or nonmetallic element, alloy, mixture, or compound used in a manufacturing operation which becomes a permanent portion of the manufactured item.

3.1.21 Material Lot

A material lot is a material produced as a single batch or in a single continuous operation or production cycle and offered for acceptance at any one time.

3.1.22 Mission Critical Component

A mission critical component is any system/circuit used on an ELV performing a function required to meet the mission objectives or flight safety requirements, regardless of redundancy or implementation scheme.

3.1.23 Nonmission Critical Component

A nonmission critical component is any system/circuit used on an ELV performing a function that is not essential to meet the mission objectives and its failure on the ground does not require replacement or causes schedule and launch delays.

3.1.24 Parts, Materials, and Processes Control Authority (PMPCA)

The PMPCA is a contractor function established to manage and control all the PMP activities including the selection, application, procurement, and documentation of parts, materials, and processes used in equipment, systems, or subsystems.

3.1.25 Parts, Materials, and Processes Selection List (PMPSL)

The PMPSL is a list of all parts, materials, and processes meeting the approved criteria for use on the program by the PMPCA.

3.1.26 Piece Part

A piece part is one piece, or two or more pieces joined together, which are not normally subjected to disassembly without destruction or impairment of its designed use. For the purposes of this document, all uses of the term “part” shall mean “piece part.”

3.1.27 Prime Contractor

A prime contractor is responsible directly to the government acquisition activity and is responsible for managing the overall Parts, Materials, and Processes Control Program. When the term contractor is used, it applies to the prime contractor.

3.1.28 Process

A process is an operation, treatment, or procedure used during fabrication of parts, subassemblies, and/or assemblies that modifies an existing configuration or creates a new configuration that alters the form, fit, function and or changes the physical and or chemical properties of the parent material.

3.1.29 Procurement Specification

A procurement specification is a document used to control the form, fit, function, quality, and reliability requirements of a procured PMP item.

3.1.30 Prohibited PMP

A prohibited PMP is a part, material, or process that has undesirable characteristics known to cause failures and cannot be used in ELV applications. See Appendices A, E, and F for the listing.

3.1.31 Program PMP Baseline

The Program PMP Baseline represents items that are selected by the contractor in accordance with Appendices B and the following:

a. Are readily available from manufacturers with demonstrated practices to yield reliable products for ELV applications

b. Are qualified to meet the ELV environments and application requirements

c. Are of acceptable quality for reliable performance in launch vehicle programs

3.1.32 Redundant System/Circuit

A redundant system/circuit is any system/circuit containing multiple independent paths performing the same function which allows the continued performance of the system/circuit within the required limits when a failure occurs in any one path.

3.1.33 Reliability Prediction

A forecast of the reliability of a system or system element. Reliability predictions are quantitative values that are usually calculated at an early design stage when little directly applicable test data are available.

3.1.34 Reliability Suspect PMP

A reliability suspect PMP is a part, material, or process that is registered with the PMPCA to document special reliability, quality, or other concerns, relating to its procurement, assembly, or application and is listed in Appendices A, E, and F.

3.1.35 Single String System/Circuit

A single string system/circuit is any system/circuit path performing a required function which can no longer be performed within the required limits when a failure occurs.

3.1.36 Single Point Failure

A single point failure is a system failure mode that can be induced by a failure mechanism in a single piece-part (mechanical or electrical), an interconnect, a multilayer board, or a mechanical gear train causing the system performance degradation or failure to meet mission requirements.

3.1.37 Subcontractor

A subcontractor is a contractor that provides products or services to another contractor.

3.1.38 Supplier/Vendor

A supplier/vendor is any organization that provides parts, materials, process, or service for use in higher order assemblies and is not a subcontractor.

3.1.39 Substitute PMP

A substitute PMP is of the same form, fit, function with lower quality, reliability, and/or survivability attributes and/or performance that can be used with restrictions in a specific application.

3.1.40 Worst Case Analysis (WCA)

A worst case analysis is an analysis used for determining whether a system or individual equipment item will meet all applicable specified performance requirements while being subjected to the most adverse combination of operating and environmental conditions.

3.2 Acronyms

ABPMPL	As-Built Parts, Materials, and Processes List
ADPMPL	As-Designed Parts, Materials, and Processes List
CAGE	Commercial and Government Entity Code
da/dn	fracture toughness and crack growth
DLA/LM	Defense Logistics Agency/Land and Maritime
DSCC	Defense Supply Center Columbus
DPA	Destructive Physical Analysis
EEEE	Electronic, Electromechanical, Electro-optical, and Electrical
ELV	Expendable Launch Vehicle
ER	Established Reliability
ESD	Electrostatic Discharge
FMECA	Failure Modes Effects and Criticality Analysis
GIDEP	Government-Industry Data Exchange Program
LAT	Lot Acceptance Test
MAR	Material Approval Request
NASA	National Aeronautics and Space Administration
PAR	Part Approval Request
PDA	Percent Defective Allowable
PED	Plastic Encapsulated Devices
PEM	Plastic Encapsulated Microcircuits
PMP	Parts, Materials, and Processes
PMPCA	Parts, Materials, and Processes Control Authority
PMPSL	Parts, Materials, and Processes Selection List
QML	Qualified Manufacturers List
QPL	Qualified Products List
RAAA	Reliability Allocations and Assessments Analysis
SCD	Source Control Drawing
WCA	Worst Case Analysis

4. Requirements

The contractor shall meet all the PMP requirements defined herein.

4.1 Parts, Materials, and Processes Control Program Planning

The contractor shall establish a Parts, Materials, and Processes Control Program in accordance with the requirements of this document. Subcontractors shall also be compliant to these requirements.

4.1.1 Parts, Materials, and Processes Control Program Plan(s)

The contractor shall establish and implement a parts, materials, and processes standardization, management and control program plan. The plan shall cover the requirements for all PMP used in mission critical components and shall be made available for review by the acquisition activity. When contractor documentation, with equivalent requirements, is used and referenced in the plan to meet the requirements herein, it shall be made available for review by the acquisition activity. The plan shall address how the contractor ensures implementation of the applicable parts, materials, and processes control program requirements as well as the flowdown of these requirements to the subcontractors. The plan shall include:

1. A PMPCA operating procedure, including resolution of PMP problems, the holding of special meetings (when to have them), membership authority, PMP review procedures, PMP approval procedures, subcontractor participation, records retention, and access

2. Procedures for selection and approval of PMP that are intended for inclusion in the Program PMP Baseline, including fault condition(s) for fault tolerant design applications and any revisions/resubmittal of a previously approved PMP

3. Definition of the contents of the PMPSL and procedures for updating, approving, and ensuring the appropriate distribution of the PMPSL

4. PMP technical requirements, including approved manufacturer, lot homogeneity and traceability control, design and construction; and quality, reliability, and performance verification to meet the design application, including PMP qualification

5. Parts and materials application derating

6. Supply chain PMP requirement flowdown, implementation, and verification

7. Procedures for inventory control

8. Policies and procedures to ensure that design engineers select PMP from the approved program PMP baseline

9. Plans and procedures for validating that the PMP received and used during manufacturing meet the baseline quality, reliability, design and construction, lot homogeneity, traceability, and performance

10. Plans and procedures for coordination between the PMPCA, design engineering, reliability, radiation, participation in anomaly and failure investigations, quality assurance, discrepant material control and disposition, and supply chain management

11. Definition of the authority of the PMPCA as it relates to various groups within the prime, and subcontractor organizations

12. Radiation Hardness Assurance Program per Appendix J, if applicable

13. Plans and procedures to meet the electrostatic discharge protection requirements of ANSI/ESD S20.20 or JESD-625 or equivalent for PMP

14. Plans and procedures for environmental (temperature and humidity) and contamination control including outgassing, clean room, foreign object debris (FOD), cleanliness of critical surfaces of piece parts and materials during shipping, storage, manufacturing, and handling

15. Plans and procedures for review and disposition of discrepant PMP

16. Descriptions and definitions of general requirements, standard clauses, format requirements, and content outlines of baseline compliant source control documents

17. Ground rules for using alternate and substitute PMP

18. Plans and procedures for identification and controlling of reliability suspect, restricted, limited usage, and prohibited PMP

19. Plans and procedures for conducting failure analysis, where required, and related review and approval procedures

20. Plans and procedures for selecting substitute PMP when the baseline quality and reliability PMP are not available to ensure the intended quality and reliability is still met for the design

21. Plans and procedures used to perform "do no harm" analyses for the use of nonmission critical components

22. Plans and procedures used for PMP counterfeit prevention and detection

23. Plans and procedures used for Acquisition Activity notification and participation in the PMPCA activities

24. Plans and procedures for evaluation, continuous monitoring, and mitigation of PMP obsolescence

4.2 Parts, Materials, and Processes Control Authority (PMPCA)

A functional organization shall be established by the contractor to manage all the PMP activities which for the purpose of this document is called a Parts, Materials, and Processes Control Authority (PMPCA). The PMPCA shall be responsible for the planning, management, and coordination of the selection, application, and procurement requirements of all parts, materials and processes intended for use in the Expendable Launch Vehicle. Acquisition Activity shall have the right of disapproval of all PMPCA decisions unless otherwise stated in the contract.

4.2.1 Membership

The PMPCA membership shall include the contractor quality assurance, component engineering, and materials and processes engineering subject matter experts to facilitate the PMPCA review as necessary the prime contractor's manufacturing, supplier/vendor/subcontractors, subcontract management, design engineering organizations etc. may be included as needed. The responsibility and accountability of each PMPCA member and technical advisor shall be clearly documented in the prime contractor's PMP control management plan.

4.2.2 PMPCA Operation

A PMPCA meeting with acquisition activity participation shall be convened by the contractor at the beginning of the program to establish initial working relationships, responsibilities, and procedures for implementation of the PMP Control Program. Plans and procedures used for Acquisition Activity notification and participation in the PMPCA activities shall also be established and agreed to at this meeting. Subsequent PMPCA meetings shall be held as necessary to implement the PMP program in a timely manner consistent with other program activities and schedules. Special PMPCA meetings may be called by the PMPCA chairperson to discuss special agenda items that require expeditious resolution. Adequate notification must be provided to all the PMPCA members and representatives. PMPCA meetings may be accomplished either in person, or virtually.

4.2.3 PMPCA Records

Records of all PMPCA decisions and the supporting technical justifications including any additional analyses and tests shall be maintained by the contractor and made available to the acquisition activity for review. The records shall be retained in accordance with the program requirements.

4.2.4 PMPCA Responsibilities

1. The contractor shall establish and maintain a program PMPSL and ADPMPL. The PMPCA shall verify that all PMP listed on the ADPMPL have been reviewed and approved by the PMPCA and are included in the PMPSL. All parts, materials, and processes approval requests and the supporting data, including qualification and evaluation plans shall be retained as part of the records documenting the PMPCA decisions per 4.2.3 herein.

2. The PMPCA shall ensure the PMP selected for the design and application meet the technical program requirements, including radiation requirements of Appendix J.

3. The PMPCA shall ensure the procurement of PMP to the baseline technical requirements. Any proposed deviations shall be approved by the PMPCA.

4. The PMPCA shall ensure all EEEE parts used in the design meet the derating requirements, including radiation and all mechanical parts and materials have adequate design margin. All PMP deviating from these requirements shall be identified as restricted limited usage, and shall be evaluated for approval in each application.

5. The PMPCA shall review and approve all DPA policies, procedures, and reporting formats for compliance with program requirements using MIL-STD-1580 as a guideline. Anomalous/ nonconforming DPA findings and summary reports shall be reviewed by the PMPCA on a regular basis.

6. The PMPCA shall review and approve discrepant/nonconforming PMP, failure analyses, GIDEP, and anomalies pertaining to PMP identified during component manufacturing, integration, test, and operation.

7. The PMPCA shall ensure that appropriate systems are in place at all program and supplier levels to identify and control changes to PMPCA approved documents. All proposed changes to the PMPCA-approved documents shall be communicated to the PMPCA for review and approval prior to implementation.

8. The PMPCA shall review and approve all substitute PMP.

9. The PMPCA shall ensure that laboratories and analysis facilities used for evaluation, screening or testing of PMP are reviewed to ensure capabilities meet program requirements in terms of facilities, equipment and personnel before performing analyses, screening or testing prior to use on the program. The PMPCA shall generate and maintain the list of approved facilities current for the program.

10. The PMPCA shall maintain the records of the PMPCA decisions for the program. These shall be made available to the acquisition activities for review in a timely manner.

11. The PMPCA shall verify the failure rates used in the reliability prediction analyses are appropriate for the part quality and reliability used in each design application.

12. The PMPCA shall review and approve all PARs, MARs, or equivalent documents.

4.2.5 PMPCA Authority

The PMPCA shall have the authority to make both technical and programmatic decisions that fall within the scope of the contract. These decisions shall be documented and the records shall be maintained and made available to the acquisition activity.

4.3 Management of PMP Selection

4.3.1 PMP Selection for Systems Designs

The contractor shall select all PMP based on the worst case application performance requirements of the hardware for the mission. When operating under these worst case conditions the PMP critical parameters shall meet the derating and radiation as defined in Appendix G and J respectively for EEEE parts and Appendix A for mechanical parts, materials (metallic and nonmetallic), and processes. Factors to be included are worst case mechanical and environmental application conditions, system level redundancy schemes, including correlation of the quality, reliability (failure rates) with redundancy schemes necessary to meet system level performance requirements, and the quality and reliability of the PMP and supplier history. Use of parts, materials, and processes that are described by the ELV Quality PMP Baseline as defined in the Appendices A, C, D, E, and L is acceptable.

4.3.1.1 PMP Supplier and Technology Evaluation

The contractor shall evaluate and assess each PMP to understand the part, material, or process to ensure its capabilities to meet mission requirements including any potential obsolescence. Critical aspects of the technology shall be evaluated to understand those physics of failure (considering the mechanical, thermal, electrical, and chemical properties) that could contribute to failures in the application throughout the product lifecycle. A failure modes effects analysis approach shall be used so that risks are identified, controlled, and mitigated through design, manufacturing, and test practices.

The contractor shall evaluate the manufacturer/supplier of the PMP items to understand the manufacturer/supplier basis for definition and control of PMP item to ensure consistency. The evaluation shall include PMP lot definition, lot homogeneity, design and construction revision, part number, manufacturing facility, tested vs. guaranteed parameters, and production runs (i.e., using the same production processes, the same tools and machinery, the same materials, the same manufacturing and quality controls, and the same baseline document revisions, and tested within the same period of time).

4.3.1.2 Electronic Part Selection

Electronic parts used in Launch Vehicle hardware shall meet the quality, reliability, and survivability requirements necessary for the application. For Category I applications only the EEEE parts that meet the ELV Quality Baseline shall be used. For Category II applications the EEEE parts shall meet the approved Program PMP Baseline as defined in the Appendix B. Use of EEEE parts that are described by the ELV Quality PMP Baseline is acceptable. All EEEE parts not used within manufacturer's application ratings and or violate the derating, and or radiation criteria shall be reviewed and dispositioned by the PMPCA for each application. For nonmission critical applications, the PMP shall be evaluated to ensure their failure would not cause harm to execute the mission.

4.3.1.3 Material and Processes Selection

The selected materials and processes for the design shall meet the required performance, reliability, safety margin, outgassing, and radiation as applicable for the design application. For Category I applications only the materials and processes that meet the ELV Quality Baseline listed in Appendix A shall be used. For Category II applications the materials and processes shall meet the approved Program PMP Baseline. For Category II use of materials and processes that are described by the ELV Quality PMP Baseline is acceptable. All materials and processes that meet the requirements or guidelines specified in Appendix A shall be considered acceptable. All materials and processes used in critical and safety applications that do not meet the requirements in Appendix A shall be dispositioned by the PMPCA. The selection of materials and processes shall be based on the following:

1. Operational requirements
2. Material or process performance
3. Manufacturing capabilities
4. Safety margins
5. Inspection criteria

4.3.1.3.1 Metallic Materials

Additional considerations for metallic materials are:

1. Acceptable initial flaw sizes, defects, and tolerances associated with the materials and manufacturing processes during fabrication and assembly

2. Relevant mechanical properties as identified in MIL-HDBK-5 or other acceptable source as approved by the PMPCA

3. Stability under environmental conditions, aging characteristics, fracture toughness, and crack growth (da/dn) under the service stresses

4.3.1.3.2 Nonmetallic Materials

Additional considerations for nonmetallic materials are:

1. Compatibility with environmental conditions
2. Specification controls over composition and processing
3. Material's shelf life and aging characteristics

4.3.1.4 Prohibited/ Reliability Suspect PMP Items

The part types and materials listed in Appendices A, E, and F shall not be used except as noted. PMP listed as reliability suspect shall not be used without PMPCA approval while the PMP listed as prohibited shall not be used under any circumstances.

In addition, the PMPCA shall ensure the implementation of procedures and processes to publish, maintain, and conduct full configuration control of a prohibited PMP items list and a reliability suspect usage PMP list.

4.3.1.5 PMP Used in Nonmission Critical Components

All PMP used on nonmission critical components shall be evaluated to ensure failure would not cause any harm to the rest of the vehicle and mission.

4.3.2 Parts, Materials, and Processes Selection List (PMPSL)

The contractor shall develop and maintain the program PMPSL based on the program PMP baseline selection criteria developed per par 4.3.1 herein. The PMPSL shall be organized to delineate and distinguish between approved parts (mechanical and electronic), approved materials (metallic and nonmetallic), and approved processes. The PMPSL shall be approved by the PMPCA and shall be made available for review to the acquisition activity. When the PMPSL is a listing of actual alpha-numeric characters for the selected parts, materials, and processes it shall be in an Excel compatible format. Each PMP listing shall contain, as a minimum, the following information:

4.3.2.1 Electrical, Electronic, Electromechanical, and Electro-Optical Parts List

The EEEE parts list shall contain the following data:

a. Part number (e.g., MIL-SPEC/SMD/DLA part number as applicable)

b. Class/level (K, V, S, etc.) (if applicable)

c. Manufacturer's part number

d. Contractor's source control drawing (SCD) or internal part number as applicable

e. Part description, nomenclature, including technology (e.g., CMOS, HBT, etc.)

f. Additional screening/test requirements (DPA, PIND, RGA, x-ray, RLAT (SEE and TID/ELDRS), Groups B, C, and/or D screenings, etc.)

g. Approved/recommended manufacturer(s)

h. Application note and/or restriction information

4.3.2.2 Mechanical Parts List

The mechanical parts shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS part number

b. Manufacturer’s part number

c. Contractor’s SCD or internal part number

d. Part description, nomenclature

e. Additional screening/test and/or preparation requirements (hardness, tensile, surface finish verification testing, etc.)

f. Approved/recommended supplier(s)

g. Application note and/or restriction information

4.3.2.3 Metallic Materials List

The metallic materials list shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS part number

b. Manufacturer’s part number

c. Contractor’s SCD or internal part number

d. Material description, nomenclature

e. Stress corrosion cracking (SCC) Rating

f. Form (bar, sheet, plate, etc.)

g. Additional screening/test or handling requirements (hardness, tensile, surface finish verification testing, etc.)

h. Approved/recommended supplier(s)

i. Application note and/or restriction information

4.3.2.4 Nonmetallic Materials List

The nonmetallic materials list shall contain the following data:

a. MIL-SPEC/SAE number

b. Manufacturer’s part number

c. Contractor's source control drawing or material specification part number

d. Material type/description/nomenclature (e.g., polyurethane/potting compound/Arathane 5753, etc.)

e. Additional screening/test or handling requirements (hardness, tensile, adhesion verification testing, etc.)

f. Outgassing data and characteristics

g. Shelf-life control requirements

h. Approved/recommended supplier(s)

i. Application note and/or restriction information

4.3.2.5 Processes List

The processes list shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS number (if applicable)
b. Manufacturer's process number
c. Contractor's internal process number
d. Type process (bonding, coating, machining, plating, soldering, etc.)
e. Special handling/process characteristics
f. Approved/recommended supplier(s)
g. Application note and/or restriction information

4.3.3 Changes to the PMPSL

Subsequent changes to the PMPSL shall be approved by the PMPCA and made available to the acquisition activity.

4.3.4 PMPSL Records

All program PMPSL records and records of subsequent changes to the PMPSL shall be maintained and kept in accordance with the program requirements.

4.3.5 Part Approval Request (PAR)

A PAR or equivalent shall be submitted to the PMPCA for all EEEE parts used in Category I applications to be included on the PMPSL that do not meet the ELV Quality PMP Baseline. For Category II, a PAR shall be submitted for all EEEE parts not meeting the approved program EEEE parts baseline. The PAR shall include as a minimum the PMPSL required information and the following:

1. Justification for the proposed applications

2. Identification of relevant GIDEP alerts, and other relevant alerts

3. Availability, including approved, proposed, and selected sources

4. Description of how the technical requirements are met, including qualification (include any appropriate test data)

5. Process methods, data, and required quality control provisions, if applicable.

4.3.6 Material and Process Approval Request (MAR)

For Category I applications a MAR or equivalent shall be submitted to the PMPCA for all mechanical parts, materials, and processes to be included on the PMPSL that do not meet ELV Baseline as defined in the Appendix A. For Category II, a MAR shall be submitted for all mechanical parts, materials and processes not meeting the approved program PMP baseline. A MAR shall include as a minimum the PMPSL information and the following:

1. Justification for the proposed applications

2. Identification of relevant GIDEP Alerts, and other relevant Alerts

3. Availability, including approved, proposed, and selected sources

4. Description of how the technical requirements are met; including qualification (include any appropriate test data)

5. Process methods, data, and required quality control provisions, if applicable.

4.3.7 As-Designed Parts and Materials List (ADPMPL)

The contractor shall document, maintain, and configuration-control the ADPMPL. The ADPMPL and the associated changes shall be made available to the acquisition activity. The ADPMPL shall contain a complete listing of all contractor and subcontractor EEEE, mechanical parts, metallic and nonmetallic materials, and processes used in the ELV components design. The ADPMPL shall clearly identify the PMP use all flight, qualification, and/or protoqualification (see SMC-S-016 for definitions) components as appropriate. All alternate and substitute PMP shall be clearly identified for each intended reference designator location use. The list shall be in Excel-compatible format but shall contain, as a minimum, the data named below.

4.3.7.1 Electrical, Electronic, Electromechanical, and Electro-Optical Parts List

The EEEE parts list shall contain the following data:

a. MIL-Spec/SMD/DLA part number (if applicable)

b. Class/level (K, V, S, etc.)

c. Manufacturer's part number

d. Contractor's source control drawing (SCD) or internal part number

e. Part description, nomenclature, including technology (e.g., CMOS, HBT, etc.)

f. Additional screening/test requirements (DPA, PIND, RGA, x-ray, RLAT (SEE and TID/ELDRS), Groups B, C, and/or D tests, etc.) placed in individual columns

g. Where used (assembly number and name of next-higher assembly)

h. Manufacturer/supplier/CAGE Code (if known)

i. PAR number (if applicable)

4.3.7.2 Mechanical Parts List

The mechanical parts shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS part number

b. Manufacturer's part number

c. Contractor's SCD or internal part number

d. Part description, Nomenclature

e. Additional screening/test and/or preparation requirements (hardness, tensile, surface finish verification testing, etc.) placed in individual columns

f. Where used (assembly number and name of next-higher assembly)

g. Manufacturer/supplier/CAGE Code (if known)

h. PAR number (if applicable)

4.3.7.3 Metallic Materials List

The metallic materials list shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS part number

b. Manufacturer's part number

c. Contractor's SCD or internal part number

d. Material description, nomenclature

e. Stress corrosion cracking (SCC) rating

f. Form (bar, sheet, plate, etc.)

g. Additional screening/test or handling requirements (hardness, tensile, surface finish verification testing, etc.) placed in individual columns

h. Where used (assembly number and name of next-higher assembly)

i. Manufacturer/supplier/CAGE Code (if known)

j. MAR number (if applicable)

4.3.7.4 Nonmetallic Materials List

The nonmetallic materials list shall contain the following data:

a. MIL-SPEC/SAE number

b. Manufacturer's part number

c. Contractor's source control drawing or material specification part number

d. Material type/description/nomenclature (e.g., polyurethane/potting compound/Arathane 5753, etc.)

e. Additional screening/test or handling requirements (hardness, tensile, adhesion verification testing, etc.) placed in individual columns

f. Outgassing data and characteristics

g. Shelf-life control requirements

h. Where used (assembly number and name of next-higher assembly)

i. Manufacturer/supplier/CAGE Code (if known)

j. MAR number (if applicable)

4.3.7.5 Processes List

The processes list shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS number (if applicable)
b. Manufacturer's process number
c. Contractor's internal process number
d. Type process (bonding, coating, machining, plating, soldering, etc.)
e. Special handling/process characteristics
f. Where used (assembly number and name of next-higher assembly)
g. MAR number (if applicable)

4.3.8 As-Built Parts, Materials, and Processes List (ABPMPL)

The contractor shall develop and maintain an "as-built" hardware configuration ABPMPL for each component installed on the ELV. The ABPMPL shall include EEEE parts, mechanical parts, materials and processes used in manufacturing and assembling of the item being delivered. The PMP items called out on engineering drawings notes and internal elements to the hybrids shall also be included.

The contractor shall identify and reconcile any differences between the "as-designed" and "as-built" PMP configuration. The ABPMPL shall include lot information and manufacturer in addition to the ADPMPL information and shall be included in the End Item Data package for each component on the Launch Vehicle and shall be made available to the acquisition activity (See SMC-S-003 for End Item Data package requirements).

4.3.8.1 Electrical, Electronic, Electromechanical, and Electro-Optical Parts List

The EEEE parts list shall contain the following data:

a. MIL-SPEC/SMD/DLA part number (if applicable)
b. Class/level (K, V, S, etc.)
c. Manufacturer's part number
d. Contractor's source control drawing (SCD) or internal part number
e. Part description, nomenclature
f. Where used (assembly number and name of next higher assembly)
g. Quantity used in each assembly
h. Supplier's name and CAGE Code
i. Lot-date-code
j. Additional screening/test report number(s) (if applicable)
k. PAR number (if applicable)

4.3.8.2 Mechanical Parts List

For mechanical parts used in critical applications, the list shall contain all the data listed below. For items issued in bulk, such as NAS hardware, data provided shall be limited to 4.3.8.2a through 4.3.8.2e.

a. MIL-SPEC/ANSI/AMS/NAS Part number
b. Manufacturer's part number
c. Contractor's SCD or internal part number
d. Part description, nomenclature
e. Where used
f. Quantity used in next-higher assembly
g. Supplier's name and CAGE Code
h. Lot-date-code/batch number
i. PAR number (if applicable)

4.3.8.3 Metallic Materials List

For metallic materials used in critical applications, the list shall contain all the data listed below. For items issued in bulk, such as solder, data provided shall be limited to 4.3.8.3a through 4.3.8.3g.

a. MIL-SPEC/ANSI/AMS/NAS Part number
b. Manufacturer's part number
c. Contractor's SCD or internal part number
d. Material description, nomenclature
e. Stress corrosion cracking (SCC) Rating
f. Form (bar, sheet, plate, etc.)
g. Where used
h. Quantity used in next-higher assembly
i. Supplier's name and CAGE Code
j. Lot-date-code/batch number
k. MAR number (if applicable)

4.3.8.4 Nonmetallic Materials List

For nonmetallic materials used in critical applications, the list shall contain all the data listed below. For items issued in bulk, such as epoxy, data provided shall be limited to 4.3.8.4a through 4.3.8.4e.

a. Material type (adhesive, coating, epoxy, gasket, insulator, sleeving, wire, etc.)

b. Material description, nomenclature

c. Outgassing data and test report number

d. Shelf-life control

e. Where used

f. Quantity used in next-higher assembly (A/R (as required) may be entered for materials where exact quantity is not available)

g. Supplier’s name and CAGE Code

h. Lot-date-code/batch number

i. MAR number (if applicable)

4.3.8.5 Processes List

The processes list shall contain the following data:

a. MIL-SPEC/ANSI/AMS/NAS number (if applicable)
b. Manufacturer’s process number
c. Contractor’s internal process number
d. Type process (bonding, coating, plating, soldering, etc.)
e. Where used (assembly number and name of next-higher assembly)
f. MAR number (if applicable)

4.4 Management of Part and Material Procurement

All parts and materials shall be procured directly from the manufacturer or procured from their authorized distributor. The selection of suppliers shall be based on criteria that include factors to ensure that the required quality and reliability requirements can be met. Each lot of parts and materials shall be traceable to the original manufacturer and shall be accompanied by a written certification of compliance to the specified requirements. The contractor shall implement plans and procedures for counterfeit PMP prevention and detection.

4.4.1 Electronic Parts Procurement Order of Precedence

The procurement order of precedence for electronic parts shall be in accordance with Appendix L for Category I PMP and Appendix B for approved Program PMP Baseline for Category II.

4.4.2 Manufacturing Baseline

The contractor shall ensure the consistency and homogeneity of electrical and mechanical parts and materials by establishing, documenting, and controlling baseline physical characteristics (e.g., construction, constituent materials, and configuration). The contractor shall ensure the manufacturer identifies any changes from the baseline on subsequent lots and or procurement of parts and materials and assess changes for impact to the original intended application.

4.5 Management of PMP Quality Assurance

The contractor shall implement PMP quality assurance procedures that meet the requirements of this document and SMC-S-003 as applicable to ensure parts and materials procured and processes used meet system requirements at the time of receipt, during production, and over the operational lifetime of the hardware.

4.5.1 General Workmanship

General workmanship shall be in accordance with the requirements of NASA-STD-8739.1-4, J-STD-001 Space Addendum or equivalent, and/or other workmanship requirements as specified in the applicable specifications and standards listed in Section 2 herein.

4.5.2 Rework/Repair of Electronic Parts

Rework of Category I or II electronic parts shall be in accordance with each specification listed in Section 2 herein.

4.5.3 Reuse of Parts and Materials

Parts and materials which have been permanently installed in an assembly using soldering, alloying, or other fusing techniques, and are then removed from the assembly for any reason, shall not be used again in any item of flight hardware without specific approval of the PMPCA.

4.5.4 PMP Qualification

4.5.4.1 General

All PMP, including any processes developed to accomplish rework or retrofit, shall require qualification for program use. PMP qualification testing shall be based on the design application and system-level redundancy schemes. Only qualified PMP shall be used on flight hardware.

4.5.4.2 Electronic Part Qualification

Electronic parts not included in the ELV quality baseline for Category I applications, shall be qualified to the requirements specified in the applicable specifications and standards for the device type. The contractor shall prepare and submit for PMPCA approval a qualification plan and procedure for those electronic parts that deviate from the qualification requirements. Category II applications parts not meeting the approved program PMP baseline shall be qualified as required for the application and as defined in Appendix B. The qualification plan shall identify all conditions and testing necessary to meet the program and mission reliability requirements and show adequate margin over expected operating conditions. Manufacturer's generic data may be used if approved by the PMPCA.

4.5.4.3 Materials and Processes Qualification

Materials and process qualification shall be the result of design studies performed during the selection process as required by para 4.3.1.3 and system testing.

4.5.5 Incoming Inspection Requirements

Each contractor shall implement, perform, or be responsible for performing applicable testing and inspections of parts and materials to ensure that they meet the requirements of the procurement specifications as directed by PMPCA. As a minimum for EEEE (Category I and II) parts, a destructive physical analysis (DPA) shall be implemented using MIL-STD-1580 as a guideline. For mechanical piece parts, metal, and nonmetal materials review of the data accompanying the lot to insure that the material meets all specified requirements (specifically the Certificate of Compliance and/or the Certificate of Analyses).

4.5.6 Failure Analysis

4.5.6.1 Failures during Assembly and Test

Failure analysis shall be performed as a minimum on part and material failures experienced during assembly-level acceptance testing (see SMC-S-016 for acceptance-level test definition). All catastrophic electronic part failures shall be analyzed to the extent necessary to understand the failure mode, failure cause, and the relation of the failure to the generic lot from which the failed part or material came from. In the case of lot-related type failures, failures shall be analyzed to the extent necessary to develop tests to detect the failure mechanism and/or corrective actions to eliminate/reduce its occurrence. Corrective action shall be determined and implemented, as applicable. The results of failure analysis shall be submitted to the PMPCA for review.

4.5.7 Data Requirements

The contractor shall establish procedures for the retention of data and records to include as a minimum incoming inspection test data, lot qualification and acceptance test data, DPA samples and results, radiation hardness assurance test data, traceability data, and other data as determined by the PMPCA for the life of the program or a period of time specified by the acquisition activity.

4.5.8 Traceability and Lot Control

The contractor shall be capable of tracing Category I and II electronic parts and materials to their manufacturer and lot identifications (i.e., lot date code, lot trace code, batch designation, or incoming inspection traceability number). Similarly, given a lot date code, or lot trace code or batch number, the contractor shall be capable of determining the unique component by serial number (and dash number) at the lowest assembly level in which the part or material is installed.

4.5.9 Inventory Control

The contractor shall implement an inventory control system that manages parts and materials consistent with each part and material requirements and to prevent adverse effect on subsequent product realization or the final product. The inventory control system shall be described in the PMP Control Plan as required by para 4.1.1 item 7.

4.5.10 Preservation and Packaging

Preservation, packaging, and packing of parts and materials shall be in accordance with both the item and the system requirements. MIL-STD-2073 should be used as a guide in the development of part and material packaging.

4.5.11 Electrostatic Discharge Sensitive (ESD) Parts

All parts which are subject to degradation by electrostatic discharge shall be marked, packaged, and handled in accordance with the approved ESD procedure referenced in para 4.1.1 item 13.

4.5.12 Handling and Storage

Handling and storage procedures shall be described in the PMP management plan as required by para 4.1.1 item 14 and shall be instituted to prevent part and material degradation. The following criteria shall be used as a minimum for establishing handling and storage procedures for parts and materials:

1. Environmental controls such as temperature, humidity, contamination, and pressure

2. Measures (procedures) and facilities to segregate and protect parts and materials routed to different locations in-house and to outside sources (for processing) such as to the materials review crib or to a laboratory for inspection or returned to the manufacturer for replacement

3. Control measures to limit personnel access to parts and materials during receiving inspection, screening, and storage

4. Provisions for protective cushioning, where required, on transportation containers to protect against accidental dropping or dislodging during transit, on storage area shelves, and in storage containers

5. Nondegrading bench surfaces on which parts and materials are handled; typical handling operations include kit organization, assembly, inspection, and test

4.5.13 Suspect Parts and Materials Control Program

The contractor shall document and implement a procedure for monitoring suspect parts, materials and processes. All parts, materials, and processes impacted by GIDEP Alerts, industry problem alert bulletins, and other agency alerts as well as those identified in Appendix F shall be considered suspect. The PMPCA shall participate in the disposition of suspect part, material, or process recommended for usage and document the technical rationale. The PMPCA shall ensure that suspect parts and materials are not selected for designs or procured for use. The PMPCA shall ensure that GIDEP Alerts are generated where applicable on lot-related rejected parts and materials or systemic problems that could affect other users.

4.6 Management of Part and Material Application

4.6.1 Electronic Part Derating

The PMPCA shall ensure the establishment of derating policies that meet system requirements. Derating policies shall address degradation of parameters and maximum rated variations expected under worst case design applications over the program mission life. Policies shall also include derating due to radiation effects, where applicable. The PMPCA shall also ensure that electronic parts used in the design meet the derating criteria specified in Appendix G. Exceptions to the derating requirements shall be technically justified and submitted to the PMPCA for limited application use on a case-by-case basis.

4.6.2 Radiation Hardness

The contractor shall develop and conduct a radiation hardness assurance program in accordance with Appendix J to meet the radiation hardness assurance requirements of the system unless otherwise specified by the contract. The hardness assurance program shall ensure the following:

1. Radiation environments are specified.

2. Radiation hardness assurance requirements and appropriate test methods are identified and documented.

3. Radiation hardness assurance representatives support the PMPCA when necessary.

The radiation hardness assurance program plan shall be documented and referenced in the Parts, Materials, and Processes Control Program Plan. All radiation hardness assurance design documentation shall be provided to the PMPCA for review and approval.

Appendix A. Mechanical Piece Parts, Materials, and Processes Requirements

1. Scope

This Appendix sets forth the procurement and testing requirements for mechanical piece parts (paragraph 2.0), metallic materials (paragraph 3.0), nonmetallic materials (paragraph 4.0), and processes (paragraph 5.0) to be used on ELV which are not included in paragraph 6.0. The requirements shall apply to both Category I and Category II applications unless otherwise called out in this appendix. The listing of mechanical piece parts, materials, and processes in paragraph 6.0 are considered approved for use on ELV and do not require PMPCA approval to use in the design.

2. Mechanical Piece Parts

2.1 Requirements

2.1.1 Application

Mechanical piece parts shall meet the requirements herein as follows: Fasteners shall meet ASME ANSI B18.18; Terminals shall meet A-A-59126; Class 3 screw threaded parts shall meet NASM1515 and NASM1312.

2.1.2 Category I

Category I mechanical piece part shall be procured in single lots directly from the manufacturer or its authorized franchised distributor. The contractor shall be able to provide objective evidence that the mechanical piece parts meet all 100% screening of all nondestructive quality conformance inspection (QCI) requirements including mechanical properties, composition, dimensions, and finish. All destructive QCI tests and screens shall be performed on a manufacturing lot sample basis as specified. The contractor is responsible for ensuring that the seller has performed all testing required and that the product meets these requirements. Copies of certifications, chemical analyses, and test data shall be provided with the mechanical piece parts. All Category I mechanical piece parts shall be listed on the Critical Items List (CIL).

2.1.3 Category II

The contractor shall select mechanical piece parts for Category II applications consistent with industry or government standards and or internal command media.

2.1.4 Outgassing

For mechanical piece parts used on the upper stage, nonmetallic materials including those used for self-locking features of fasteners or lubrication shall meet the outgassing requirements of 1% TML and 0.1% CVCM.

2.1.5 Fastener Installation

The mechanical fasteners installation processes and associated parts shall be documented and shall be shown by analysis and/or test to meet the design application.

In addition, the following requirements are specific to launch vehicles.

a. Fastener management and control policy, responsibilities, and practices for Category I fasteners shall meet program requirements and paragraph 2.1.2 above.

b. Liquid locking compounds shall not be used as secondary locking features for Category I applications.

c. Liquid locking compounds used as a secondary locking feature in Category II applications shall only be used if approved by PMPCA and have validated processes.

d. Self-locking fastener reuse shall not be allowed.

e. Fasteners shall be wet installed when exposed to aqueous corrosive environments and/or applications where condensation can occur. Only corrosion-resistant sealant shall be used, and installing the fastener shall be complete while the sealant is still wet.

f. The installation of titanium fasteners and associated parts shall meet the requirements of MSFC-STD-557.

2.1.6 Reliability Suspect

a. Lubricants and other materials on fasteners is a concern on systems with critical cleanliness requirements. In such instances, fasteners shall be precleaned prior to usage.

b. Cold Flow Susceptibility. Materials that have a potential to cold flow, such as Teflon used to insulate terminals and lugs, shall be evaluated prior to use for cold flow potential in the selected application.

c. Formate Lock Washers. Lock washers (either split type or star type) shall not be used as locking devices for space mechanisms. By "biting" into the surface, they often damage it and create debris. In addition, their overall effectiveness is poor.

d. Use of solder-coated/plated washers shall be controlled to ensure solder does not creep under a torque load or cause whisker growth.

2.1.7 Prohibited Mechanical Piece Parts

a. Parts containing prohibited materials in their construction or finish as defined herein shall be prohibited for use.

3. Metallic Materials

3.1 Requirements

3.1.1 Mechanical Strength Allowables

Structural metallic components shall be designed using the A-basis allowables of the relevant mechanical properties identified in MIL-HDBK-5, MMPDS (Metallic Materials Properties Development and Standardization) or other sources or test programs as approved by the PMPCA.

3.1.2 Fracture Critical Metallic Materials

Metallic materials used in fracture-critical applications shall have fracture toughness and fatigue crack growth rate sufficiently characterized to enable the verification of safe-life and damage tolerance behavior in accordance with AIAA-S-110, AIAA-S-080, AIAA-S-081A, and NASA-STD-5019. Fracture mechanics properties for the relevant operating temperature and chemical environments shall be verified on representative samples from each material and heat lot that have undergone the same manufacturing processing.

3.1.2.1 Material Anisotropy

For metallic materials that demonstrate anisotropic behavior, fracture properties shall be determined for all material orientations. Unless material orientation specified in the design is maintained and traceable throughout manufacturing, the properties along the weakest direction shall be used in the life and strength analysis.

3.1.3 Corrosion

Metallic materials shall be corrosion resistant over the expected environment and operating temperature or shall be suitably protected from corrosion, including via the methods described in NASA-STD-6012 or equivalent.

3.1.3.1 Corrosion Prevention and Control

All parts, assemblies, and equipment, including spares, shall be finished to provide protection from corrosion. The contractor shall ensure that corrosion prevention and control measures are integrated during system definition, engineering development, design and production, and operational phases.

3.1.3.2 Protective Finishes

The requirements for and application of protective finishes, including cleaning prior to application, shall be in accordance with NASA-STD-6012, with the exception of zinc, cadmium, and pure tin finishes.

3.1.3.3 Stress Corrosion Considerations

Alloys and associated heat treatments, which have a high resistance to stress corrosion cracking (SCC) as defined in MSFC-STD-3029 Table 1 shall be utilized in all structural, load-carrying applications.

When a material is susceptible to SCC, particular emphasis in design, fabrication, and installation of parts is required to prevent sustained tensile stresses from exceeding the stress corrosion threshold limitations for the material and the grain-flow orientation. Stress corrosion threshold values are determined by actual testing as described in 3.1.2.4 below. Materials that are subject to stress corrosion cracking conditions and do not have a high resistance to stress corrosion cracking as defined in MSFC-STD-3029 Table 1 shall be considered a nonstandard material and shall require program PMPCA approval.

3.1.3.4 Stress Corrosion Threshold

For materials with no published stress corrosion data or use history, the contractor shall develop values based on the material’s ability to withstand exposure to alternate immersion tests in 3.5% sodium chloride solution (10-minute immersion and 50-minute drying time) for 180 days without cracking as detectable by Class AA ultrasonic inspection in conformance with SAE-AMS-STD-2154 or for 30 days without cracking as detectable by sectioning and metallographic examination or salt spray when tested in accordance with ASTM-13117 (168 hours for aluminum alloys and 336 hours for steel alloys) without cracking. Alternate technically equivalent test methods may be used provided they are proven to be equivalent. This data shall be retained by the contractor and be available for PMPCA review.

3.1.3.5 Galvanic Corrosion

Dissimilar metals, as defined by Table 1 of MIL-STD-889, shall not be allowed in contact with one another. Incompatible materials shall be identified and protected in accordance with MIL-STD-889 or equivalent, and their use shall be approved by the PMPCA.

3.1.4 Forgings

3.1.4.1 Forging Design

Forgings shall be produced in accordance with SAE-AMS-F-7190 for steel, SAE-AMS-A-22771 or SAE-AMS-QQ-A-367 for aluminum alloys and SAE-AMS-T-9047 for titanium alloys. Recognized industrial association or contractor specifications shall be used for alloys not covered by the above specifications.

a. Because mechanical properties are maximized in the direction of material flow during forging, forging techniques shall be used that produce an internal grain flow pattern such that the direction of flow in all stressed areas is essentially parallel to the principal tensile stresses in the intended application.

b. The forging pattern shall be free from reentrant and sharply folded flow lines.

c. After the forging parameters, including degree of working, are established, a sample from the first production forging shall be sectioned to show the grain flow patterns and to determine mechanical properties and fracture toughness values at control areas.

d. The procedure shall be repeated after any significant change in the forging parameters.

e. Test data, material samples, and results of the tests on redesign shall be retained by the contractor as required by the program.

f. For Category I applications, forging shall require first article (preproduction) approval

3.1.4.2 Forging Surfaces

Surfaces of structural forgings in regions identified by analyses as critical fatigue or in regions of major attachment shall be shot peened or placed in compression by other means demonstrated to be equivalent. Those areas of forgings requiring lapped, honed, or polished surface finishes for functional purposes shall be shot peened prior to surface finishing operations.

3.1.4.3 Forging Residual Stresses

Residual stresses normally induced into manufactured parts as a result of forging, machining, heat-treating, welding, special metal removal processes, and assembly shall be eliminated or minimized by appropriate heat treatments, such as annealing and stress relieving, and process optimization.

3.1.5 Castings

Castings shall be classified and inspected in accordance with SAE-AMS-2175. Structural castings shall be procured to guaranteed properties, premium quality specifications, including SAE-AMS-5343, or other document in accordance with the contractor's approved PMP control plan.

3.1.6 Composite Materials

Composite materials containing graphite fibers shall be treated as graphite in MIL-STD-889.

3.2 Aluminum and Aluminum Alloys

3.2.1 Application

In structural applications requiring the selection of aluminum alloys, maximum use shall be made of those alloys, heat treatments and coatings which minimize susceptibility to general corrosion, pitting, intergranular and stress corrosion, and maximize fracture toughness.

3.2.2 Special Considerations

3.2.2.1 Aluminum Heat Treatment

Heat treatment of wrought aluminum alloys shall meet the requirements of MIL-H-6088G (S/S by SAE-AMS-H-6088, 9/26/97), and the heat treatment of wrought aluminum alloy parts shall meet the requirements of SAE-AMS-2770. Heat treatments not included in above specifications may be used if test data is available to prove that the specific heat treatment improves the mechanical and/or physical properties of the specific aluminum alloys without altering susceptibility to degradation. This data shall be retained by the contractor and is subject to review.

3.2.2.2 Chemical Finishes for Aluminum Alloys

3.2.2.2.1 Anodic Coatings

All other processing, such as welding, machining, forming, heat treating, etc., shall be completed prior to anodizing to prevent cracking of the anodic coating.

3.2.2.2.1.1 Design Limitations for Anodic Coatings

When anodic coatings are specified, the design shall account for dimensional build-up of the coating. The thickness of anodic coating applied to threads shall account for maintaining the thread form. The expected thicknesses of anodic coatings per MIL-A-8625 are as follows:

Type I: 0.00005 – 0.003 inches
Type II: 0.00010 – 0.0010 inches
Type III: 0.00050 – 0.0045 inches

a. To insure uniform anodic coating thickness inside recesses and holes, the maximum depth-to-diameter ratio shall be 2 for blind holes and 7 for open holes.

b. The use of Type III hard anodize shall account for the expected reductions in tensile strength of up to 10% and fatigue strength.

c. Parts to be coated with Type III anodize shall be free of sharp edges or corners:

Nominal coating thickness, inches	Approx. radius of curvature, inches
0.001	1/64
0.002	1/32

0.003	1/16
0.004	3/32

d. The engineering drawing shall specify critical areas to allow for small areas of no coverage where electrical contact cannot be made during the anodizing process.

3.2.2.2.1.2 Alloy Restrictions

a. Conventional chromic acid process, MIL-A-8625, Type I, shall not be used on 2219, 4032, 7075, and 7079 alloys. (Type II conventional sulfuric acid process shall be used for these alloys.)

b. Chromic acid process, MIL-A-8625, Type I, shall not be used to anodize aluminum alloys castings containing greater than 5% copper or more than 7.5% total alloying elements. Excessive pitting or burning may result.

c. MIL-A-8625, Type III anodic coating shall not be applied to aluminum alloys with a nominal copper content in excess of 5%, such as 2219 aluminum alloy.

d. Application of anodic coatings to aluminum alloys with a nominal silicon content higher than 8% shall be subject to PMPCB approval.

3.2.2.2.1.3 Environmental Limitation of Anodic Coatings

Anodic coatings shall not be exposed to temperatures above 300°F to prevent crazing due to the difference in the thermal expansion rates between the base metal and coating.

3.2.2.2.2 Chemical Conversion Coatings

Chemical conversion coating shall be utilized to provide corrosion protection for electrical and electronic applications where low contact is required in accordance with MIL-C-5541, Class 3.

3.2.2.2.2.1 Chemical Conversion Processing

All processing operations, including heat treatment and all mechanical operations, shall be completed prior to application of conversion coating.

3.2.2.2.2.2 Environmental Limitation

The conversion coating shall not be exposed to temperatures greater than 140°F.

3.2.2.3 Alloy and Temper Restrictions

Aluminum alloys 2020-T6, 7079-T6, and 7178-T6 shall not be used for structural applications unless specifically approved by the PMPCA. The use of 7075-T6, 2024-T3, 2024-T4, and 2014-T6 sheet (less than 0.25 inches thick) material is allowed only in the case where the short transverse loads (design, fit-up, thermal, and residual) are below acceptable stress corrosion limits and that proven corrosion protection systems are provided. Other forms of 7075 shall be heat-treated to the -T3 temper.

3.2.2.4 Aluminum Forming and Straightening

Forming and straightening operations shall be limited to processes that do not result in stress corrosion sensitivity of the part, or to detrimental residual stresses, or losses in mechanical properties, or fracture toughness on structurally critical parts. The contractor shall maintain controls and data to support the use of the forming and straightening processes. These controls and data are subject to review.

3.2.2.5 Aluminum Casting

Aluminum alloy castings for electronic boxes and other structural applications should meet the requirements of SAE-AMS-A-21180.

3.2.2.6 Stress Corrosion Cracking

Alloys and heat treatments, which result in a high resistance to stress corrosion cracking as defined in MSFC-STD-3029 Table 1, shall be utilized in all structural, load-carrying applications. Use of materials that are subject to stress corrosion cracking conditions and do not have a high resistance to stress corrosion cracking as defined in MSFC-STD-3029 Table 1 shall only be allowed for Category II applications with PMPCA approval.

3.2.2.7 Aluminum Welding

The welding of aluminum alloys for high strength applications shall meet the requirements of MSFC-SPEC-3679. Alternate welding specifications are allowed only if sufficient data is available to substantiate that the specification is satisfactory for the intended application. Supporting data for the use of alternate welding specifications shall be available for review by the PMPCA upon request.

3.2.3 Prohibited aluminum and aluminum alloys shall include:

a. Alloys with a stress corrosion threshold less than 25 ksi in any grain direction
b. Aluminum alloy 5083-H32, where temperature > 150°F
c. Aluminum alloy 5083-H38, where temperature > 150°F
d. Aluminum alloy 5086-H34, where temperature > 150°F
e. Aluminum alloy 5086-H38, where temperature > 150°F
f. Aluminum alloy 5456-H32, where temperature > 150°F
g. Aluminum alloy 5456-H38, where temperature > 150°F
h. Mercury and mercuric compounds in aluminum alloys

3.3 Beryllium (Be)

3.3.1 Application

Items containing Be and Be alloys with greater than 5% Be shall be clearly marked as containing these materials, with a warning calling attention to the hazards of machining and handling beryllium.

3.3.2 Special Considerations

3.3.2.1 Toxicity

The toxicity of Be dust and fumes is a critical problem, and precautions shall be taken to minimize exposure during fabrication, assembly, installation, and usage of Be parts.

3.3.2.2 Storage

Be products that may generate dust or particles shall be stored in closed containers, which shall only be opened in a controlled environment.

3.3.3 Design

The design of Be parts shall be limited. Be parts shall be tested under simulated service conditions and exhibit mission life, including any expected corrosive environments to verify Be low impact resistance, the notch sensitivity, over temperatures, directional material properties (anisotropy), and sensitivity to surface finish requirements adversely affect performance.

3.4 Cadmium

a. Cadmium shall not be used in crew or vacuum environments.
b. Cadmium-plated tools shall not be used in the manufacture of flight hardware

3.5 Copper and Copper Alloys

3.5.1 Application

a. Copper and copper alloys shall be used in applications that require high electrical and/or thermal conductivity combined with excellent fabrication characteristics and good corrosion resistance. The most common copper alloy compositions are as follows:

b. Oxygen-free high-conductivity (OFHC) copper (CA 101 and 102) shall be used in applications requiring high electrical or thermal conductivity.

c. Beryllium copper (CA 172) shall be used for high strength, good corrosion resistance, and high electrical conductivity. Typical applications include springs, bellows, diaphragms, valves, cams, gears, fasteners, bushings, and contacts.

d. Cartridge brass (70% Cu-30% Zn, CA 250), a nonheat-treatable copper alloy, shall meet the requirements of QQ-B-626.

3.5.2 Heat Treatment

3.5.2.1 Beryllium Copper C

Beryllium copper can develop a wide range of mechanical properties, depending on solution treating and aging conditions and on the amount of cold work imparted to the alloy. Heat treatment of beryllium copper alloys shall meet the requirements of SAE AMS-H-7199.

3.5.2.2 Annealing

When annealing copper that contains oxygen, the hydrogen in the atmosphere shall be kept to a minimum to avoid embrittlement. For annealing temperatures below 480°C, hydrogen content shall not exceed 1%.

3.5.3 Design Constraints

a. Designs utilizing beryllium copper shall take into account a contraction of up to 0.003 inch per inch occurs during the precipitation hardening treatment. The contraction will occur more rapidly in areas that are in compression (residual or applied), resulting in part distortion.

b. Designs utilizing brass shall consider the potential for zinc sublimation at vacuum and/or at elevated temperatures.

3.5.4 Joining

Furnace and induction brazing of copper alloys shall be performed in a protective atmosphere, such as argon, hydrogen, or vacuum.

Spot- and seam-resistance welding shall not be used to join copper due its high thermal conductivity.

3.5.5 Limitations

a. Copper and copper alloys shall be used with some corrosion protection finish to prevent surface reaction with sulfur during atmospheric exposure.

b. OFHC copper is susceptible to creep and fatigue and shall not be used to provide structural strength.

c. Copper shall not be exposed to nitrogen tetroxide propellant.

d. Gold plating shall not be directly applied to copper and copper alloys. An electroplated nickel is required as a diffusion barrier.

e. Electroless nickel plating shall not be used as an underplate.

3.6 Heat-Resistant Alloys (Nickel-Based and Cobalt-Based) Superalloys

3.6.1 Application

a. High-nickel content alloys are susceptible to sulfur embrittlement; therefore, any foreign material which could contain sulfur, such as oils, grease, and cutting lubricants, shall be removed by suitable means prior to heat treatment, welding, or high temperature service.

b. Thin sheets shall be evaluated for alloying element depletion at the surface in a high-temperature oxidizing environment using cross sections or other suitable means.

c. Common superalloys used in space applications are as follows: Hastelloy C, Hastelloy X, Inconel 600, 625, 718, X750, Nickel 200, 201, 205, Waspaloy; and copper alloys CDA 101, CDA 102, OFHC, CDA 110, Be-Cu CDA 170, CDA 172, and pure copper wire.

3.6.2 Heat Treatment of Nickel- and Cobalt-Based Alloys

a. Heat treatment of nickel- and cobalt-based alloy parts shall meet the requirements of SAE-AMS-2774, Heat Treatment, Wrought Nickel Alloy, and Cobalt Alloy Parts.

b. When nickel- and cobalt-based alloys are work strengthened before age hardening, resulting in age-hardened tensile strengths greater than 1030 MPa (150 ksi) UTS, representative production lot process-control tensile-test coupons shall be taken to verify the adequacy of the heat treatment process.

c. When tensile test coupons are not required, the adequacy of the heat-treatment process shall be verified by hardness measurements.

3.6.3 Stress Corrosion Cracking

For those metals and alloys which are not covered in MSFC-STD-3029 or which have no available stress corrosion data or documented use history, the contractor shall demonstrate through testing in accordance with MSFC-STD-3029 that the metal or alloy is free from stress corrosion cracking from the environment and stress level in its application.

3.6.3.1 Joining

Joining of alloys shall meet the following requirements:

a. A286 CRES alloys shall be welded in the solution treated (ST) condition to prevent hot cracking, particularly in the solution treated and aged (STA) condition.

b. L-605 (also known as Haynes 25) shall require solution treatment (2250°F, followed by rapid air-cool or water quench) after each stage of cold work.

c. Brazing of L-605 shall be performed in a dry hydrogen atmosphere or vacuum.

3.6.3.2 Corrosion

Inconel 600 nickel alloy in the cold-worked, high-strength condition shall not be used in the presence of mercury at elevated temperatures to prevent cracking. Inconel 718 is susceptible to sulfur embrittlement. At room temperature, it is subject to stress corrosion cracking in high pressure hydrogen (1000 psi or greater) but becomes insensitive to high pressure hydrogen at -160F.

3.7 Magnesium (Mg)

3.7.1 Application

Magnesium alloys shall not be used for structural applications in any area subject to wear, abrasion, or erosion, or where fluid entrapment is possible. Mg alloys shall not be used except in areas where exposure to corrosive environments is prevented and protection systems are maintained.

3.7.2 Heat Treatment

Magnesium alloys shall be solution heat treated in a controlled atmosphere due its tendency to oxidize in air at temperatures exceeding 750°F. Heat treatment shall meet the requirements of ASTM B661 or SAE-AMS-2768.

3.7.3 Special Considerations

3.7.3.1 Stress Corrosion Cracking

Magnesium and magnesium alloy products shall be heat treated after forming to avoid stress corrosion cracking.

3.7.3.2 Corrosion

Magnesium and magnesium alloy products shall not be used without a corrosion protection system designed for its mission, manufacturing, and storage environment.

3.7.3.3 Dissimilar Metals

Dissimilar metal protection shall be used regardless of the environmental controls.

3.8 Mercury

a. Equipment containing mercury shall not be used where the mercury could come in contact with the spacecraft or spaceflight equipment during manufacturing, assembly, test, checkout, and flight.

b. Flight hardware (including fluorescent lamps) containing mercury shall have three levels of containment to prevent mercury leakage.

c. The bulbs of nonflight lamps containing mercury such as those used in hardware ground processing and fluorescent dye penetrant inspection of flight parts shall be protected by a shatter-resistant, leak-proof outer container.

3.9 Refractory Metals

All refractory alloys (alloys with a melting point above 2000°C (3600°F) plus osmium and iridium) shall require characterization tests for the intended applications and PMPCA approval prior to use for all applications.

3.9.1 Special Considerations

3.9.1.1 High Temperature Oxidation Resistance

Due to their poor oxidation resistance at high temperatures, refractory metals and their alloys shall not be used at elevated temperatures in an oxidizing atmosphere without a protective coating.

Joining processes, such as welding and brazing, shall be performed in vacuum or protective atmosphere, free of oxygen and nitrogen.

3.9.1.2 Brittleness

Molybdenum and tungsten alloys are brittle at room temperature; thus, they shall not be used for subzero applications.

3.9.1.3 Stress Relief

Weldments shall be stress relieved, or recrystallized, for maximum postweld ductility.

3.10 Steels

3.10.1 Application

High-strength steels heat-treated at or above 180 ksi UTS shall not be used unless approved by the PMPCA. Also, the effect of low temperature on reducing high-strength steel toughness and ductility shall be considered in the design and application of these steels.

3.10.2 Special Considerations

3.10.2.1 Heat Treatment of Steels

a. Steel parts shall be heat-treated as specified to meet the requirements of SAE-AMS-H-6875 or SAE-AMS-2759.

b. Coupons shall be included to cover the entire fabrication cycle steps for all high-strength steel parts heat-treated to or above 180 ksi UTS.

c. All other steels, including alloy steels heat treatment, shall be verified through hardness testing measurements.

d. Hydrogen embrittlement relief per SAE-AMS-2759/9 shall be implemented whenever acid cleaning baths or plating processes are used on steels.

e. Heat treatments not included in SAE-AMS-H-6875 or SAE-AMS-2759 shall not be used unless approved by the PMPCA and demonstrate that the heat treatment improves the mechanical and/or physical properties of the specific steel without altering susceptibility to degradation.

3.10.2.2 Drilling and Machining of High-Strength Steels

The drilling of holes, including beveling and spot facing, in martensitic steel hardened to 180 ksi UTS or above shall unless carbide-tipped tooling and other techniques necessary to avoid formation of untempered martensite is used.

In-process test specimens shall be processed with the part, and micro-hardness measurement and metallurgical examination of these specimens shall be used to determine if martensitic areas are formed as a result of drilling or machining operations.

The surface roughness of finished holes shall not be greater than 63 roughness-height ratio (RHR), and the ends of the holes shall be deburred by a method which has been demonstrated not to cause untempered martensite.

3.10.2.3 Grinding of High-Strength Steels

Grinding of martensitic steels and chromium-plated martensitic steels hardened to 180 ksi UTS and above shall meet MIL-STD-866.

3.10.2.4 Corrosion Resistant Steels

3.10.2.4.1 Austenitic Stainless Steels

a. Free-machining stainless steels shall not be used in fatigue-critical applications or where they can get wet.

b. Unstabilized, austenitic steels shall not be used above 371°C (700°F).

c. Welded assemblies shall be solution heat-treated and quenched after welding except for the stabilized or low carbon grades such as 321, 347, 316L, and 304L.

3.10.2.4.2 Precipitation Hardened Stainless Steels

Stainless steels that can be precipitation-hardened shall be aged at temperatures greater than 1000ºF, except as follows:

a. Castings that may be aged at 935ºF ±15ºF
b. Fasteners that may be used in the H950 condition
c. Springs which have optimum properties in the CH 900 condition

3.10.2.5 Forming or Straightening of Steel Parts

Procedures and tooling shall be used to minimize warping during heat treatment of steel parts. Steel parts shall be formed or straightened as follows:

a. Parts hardened from 165 to 200 ksi UTS shall be given a stress relieving heat treatment subsequent to room temperature straightening

b. Parts hardened over 200 ksi UTS shall be hot formed or straightened within a temperature range of the tempering temperature to 50ºF below the tempering temperature

3.10.2.6 Shot Peening

All surfaces of Category I parts which have been heat-treated to or above 200 ksi UTS shall be shot peened in accordance with SAE-AMS-S-13165 except for:

a. Rolled threads, inaccessible areas of holes, pneumatic or hydraulic seat contact areas

b. Thin sections or parts which if shot peened could violate engineering and functional configuration

Areas requiring lapped, honed, or polished surfaces shall be shot peened prior to finishing.

3.10.2.7 Stress Corrosion Cracking

The assembly stresses of low alloy steel heat-treated above 200 ksi UTS shall not exceed the stress corrosion threshold limitation for the particular material and grain-flow orientation.

3.10.2.8 Low-Alloy, High-Strength Steel Corrosion Prevention

All low-alloy, high-strength steel parts heat-treated at 180 ksi UTS and above, including fasteners, shall require corrosion preventative metallic coatings by a process that does not cause embrittlement of the alloy/heat treatment combination.

3.11 Titanium

3.11.1 Procurement

Titanium sheet, plate, bars, and forged bar stock shall be procured to meet the requirements of AMS specifications for the specific alloy and the additional contractor requirements as applicable.

All titanium extruded bars, rods, or special shaped sections shall be procured from the titanium original equipment manufacturer (OEM) or its franchised distributor to meet the requirements of MIL-T-81556 and the additional contractor requirements as applicable.

3.11.2 Heat Treatment

Titanium alloys are heat-treated for the purposes of strengthening, softening, cold-worked, or hardened material. Heat treatment of titanium and titanium alloy products shall be in accordance with MSFC-SPEC-469. For titanium alloy products not covered in MSFC-SPEC-469, heat treatment shall be in accordance with SAE-AMS-H-81200.

Process-control tensile-test coupons shall be taken from each production heat treated lot to verify the adequacy of the heat treatment process.

When titanium and titanium alloys have been processed at elevated temperature in an oxidizing environment, including milling, heat treating, and forming operations, surfaces shall be 100% machined, chemically milled, or pickled to a sufficient depth to remove all contaminated surface layers.

3.11.3 Special Considerations

3.11.3.1 Hardenability

Titanium alloys shall not be used in sections which exceed their hardenability specified limits.

3.11.3.2 Titanium Forgings

All titanium bar and forging stock shall be procured in accordance with the requirements of SAE-AMS-T-9047 supplemented by contractor metallurgical and structural requirements to meet the application reliability and durability requirements.

3.11.3.3 Titanium Contamination

Titanium and titanium alloys shall not come in contact with the following materials during manufacturing and assembly:

a. Hydrochloric acid
b. Silver
c. Halogenated solvents
d. Methyl alcohol

e. Mercury and mercuric compounds
f. Trichloroethylene/trichloroethane
g. Carbon tetrachloride
h. Halogenated cutting oils
i. Halogenated hydrocarbons
j. Cadmium or silver plated clamps, tools, fixtures, or jigs

3.11.3.4 Fretting of Titanium

Components manufactured with titanium and titanium alloys shall be designed to prevent fretting.

Areas prone to fretting or wear shall be either anodized or coated with a wear-resistance material such as tungsten carbide/cobalt thermal spray.

3.11.3.5 Titanium Corrosion Considerations

When titanium and titanium alloys have been processed at elevated temperature in an oxidizing environment, including milling, heat treating, and forming operations, surfaces shall be 100% machined, chemically milled, or pickled to a sufficient depth to remove all contaminated surface ayerstions.

3.11.3.6 Titanium Welding

a. Titanium and its alloys shall be welded with alloy-matching fillers or autogenously.

b. Extra low interstitial (ELI) filler wires shall be used for cryogenic applications.

c. Commercially pure (CP) titanium filler shall not be used on 6-4 titanium or other alloyed base material.

d. Only inert gasses (argon or helium) with a dew point of -60ºC (-76ºF) or lower shall be used.

e. Nitrogen, hydrogen, carbon dioxide, and mixtures containing these gases shall not be used in welding titanium and its alloys.

f. Welded alpha and alpha-plus-beta alloys shall be stress relieved in a vacuum or inert gas environment (Ar or He).

g. Stress relief in Beta alloys that are welded shall be evaluated on a case-by-case basis.

3.11.3.7 Titanium Flammability

a. Titanium alloys shall not be used with LOX or GOX at any pressure or with air at oxygen partial pressures above 35 kPa (5 psia).

b. Titanium alloys shall not be machined inside spacecraft modules during ground processing or in flight.

3.12 Zinc and Zinc Containing Alloys

a. Zinc and zinc containing alloys shall not be used in vacuum environments where the temperature/pressure environment could cause contamination of optical surfaces or electrical devices.

b. Zinc plating shall not be used on surfaces without proven mitigation strategies to prevent whisker growth implemented.

4. Nonmetallic Materials

4.1 General Requirements

a. Nonmetallic materials shall be selected and qualified for each application. The rationale and qualification data shall be maintained and available for review. The consideration of the following, as a minimum, shall be evaluated:

b. Design engineering properties

c. Application operational requirements

d. Compatibility with other materials used

e. Material hazards and restrictions as specified in Section 4, General Requirements, and paragraph 4.3.2 of this document

f. Environmental and health restrictions mandated by applicable federal, state, and local regulations

4.1.1 Composition and Processing

Composition and processing used shall be documented to ensure a product that is reproducible and meets all physical, chemical, and mechanical requirements of the intended application.

4.1.2 Compatibility

Nonmetallic materials shall be selected based on any combination of the following:

a. Manufacturer data,
b. Material evaluation
c. Material or component tests
d. Documented and detailed history

Selected materials shall be compatible with temperature, pressure, radiation, and fluid or gas environments.

Tests for compatibility with hazardous fluids and gases such as oxygen or hydrogen shall consider energy sources available in the proposed application that could initiate adverse reactions.

4.1.3 Outgassing

Organic/polymeric materials used in upper-stage compartments that are not hermetically sealed with a maximum leakage of 5 × 10-4 cc/sec of helium, when tested at a pressure of 1 × 10-5 torr, shall have a maximum total mass loss (TML) of 1.0% of the original specimen mass and a maximum collected volatile condensable material (CVCM) content of 0.1% of the original specimen mass when tested in accordance with ASTM-E-595. Exceptions to these requirements shall be approved by the PMPCA.

4.1.4 Stability

The materials shall be hydrolytically stable and not subject to reversion for their intended environments including manufacturing, testing, transportation, and storage.

4.1.5 Storage

Polymers that are procured in noncured or partially cured states, i.e., prepregs, frozen premixes, etc., shall be held in controlled temperature storage. Specific requirements for storage, such as temperature and humidity, shall be as recommended by the manufacturer. A first-in/first-out policy shall also be maintained.

4.1.6 Work Life

The manufacturer's recommended work life and out time for noncured and partially cured polymeric materials shall be compatible with the manufacturing environment and the maximum processing time.

4.1.7 Chlorinated Fluorocarbons (CFCs)

All polymeric materials shall be free of CFCs as mandated by federal or state regulations.

4.1.8 Electrical Insulation

Use of polytetrafluorethane, Teflon® FEP, Kel-F, polyimide, polyamide (nylon), polyurethane, polycarbonate, polyethylene, polyalkene, polyethyleneterephthalate, polyolefin, polysulfone, and silicone sleeving in all grades of materials for insulation is acceptable. Where materials other than these are required, fungus-resistant classes shall be specified and their performance established by testing per MIL-STD-810.

Vinyl and polyvinylchloride shall not be used as insulation on wiring or as sleeving because of their fungus nutrient characteristics and the dangers of outgassing during storage. These organics give off corrosive vapors, which actively attack metals, plastics, elastomers, and insulation.

Fluoropolymers such as PTFE, Teflon® FEP, and TFE cold flows shall not be used under pressure such as against sharp edges and in sharp bend configurations. Failures due to electrical shorts or degradation from radiation environments may occur.

4.1.9 Fungus-Inertness

Nonmetallic materials shall be fungus inert. Use of nonfungus inert materials shall require PMPCA approval together with their fungus prevention mitigation strategies.

4.1.10 Flammability

Nonmetallic materials shall meet the flammability hazards in accordance with NASA-STD-6001 or equivalent.

4.1.11 Environmental Compatibility

Nonmetallic coatings and adhesives shall not crack, chip, peel, or scale with age when subjected to anticipated environmental extremes or normal handling during the manufacturing, integration and test, and flight conditions.

4.1.12 Mechanical Property Allowables

Nonmetallic materials with a structural application shall be designed with A-basis allowables. A-basis allowables shall either be generated or, alternatively when using industry sources of data, the data shall be verified for each manufacturer.

4.1.13 Shelf-Life Limitations

The polymeric materials shall be stored under the manufacturer-recommended conditions. The contractor shall document and implement a shelf-life control program for all flight polymeric materials. The program shall be approved by the PMPCA and shall identify useful shelf life and shelf-life extension (maximum number of extensions allowed, testing requirements, discard date, and justification) for each individual material.

4.1.14 Contamination Analysis

The hygroscopic nature of materials shall be factored in the contamination analysis.

4.2 Elastomeric Materials

4.2.1 Application

Elastomeric materials shall meet the applicable launch system requirements, including resistance to heat aging, low temperatures, ozone, polymer reversion, and compatibility with working fluids, lubricants, propellants, and oxidizers.

4.2.2 Special Considerations

4.2.2.1 Cured Elastomers

Cured elastomers shall be controlled in accordance with SAE-AS1933 and SAE-ARP5316. All cured elastomeric materials shall be cure-dated for age sensitivity tracking purposes. Cured elastomeric materials shall be protected from sunlight, fuel, oil, water, dust, and ozone and shall be stored at room temperature or at temperatures below 37.8ºC (100ºF).

4.2.2.2 Uncured Elastomers

Materials that are procured in uncured state such as sealants, adhesives, and potting compounds shall be stored under controlled conditions as defined by the manufacturer. The shelf life of uncured elastomers shall be documented in the PMPCA-approved shelf life control plan.

4.2.2.3 Propellant Compatibility

Elastomeric materials in contact with hydrazine shall be restricted to AF-E-332 and AF-E-411 as defined by Air Force Material Lab Report TR71-59, Part II. The use of other elastomeric materials including insulation, liner, bladder, and seal ants shall require the approval of the PMPCA.

4.2.2.4 Low-Temperature Operations

Low-temperature applications shall be limited by the brittle point of the elastomer.

4.2.2.5 Prohibited Elastomers

a. One-part room-temperature vulcanizing (RTV) silicones, including commercial adhesives and sealants as well as those meeting MIL-A-46106 that liberate acetic acid during cure, shall not be used to pot, seal, embed, or encapsulate near avionics, electronics, or electrical equipment since they can cause corrosion.

b. Natural rubber materials.

4.3 Foamed Plastics

4.3.1 Application

Foamed plastics used shall be hydrolytically stable and shall not be subject to reversion. Foamed plastics shall be applied in a manner that prevents damage to fragile components or results in damage to adjacent surfaces. Testing or analysis shall be done and be available for review that demonstrates that foamed plastics meet these requirements for their intended application.

4.3.2 Outgassing and Flammability

Only a few foamed plastics meet outgassing and flammability requirements. Often such materials require baking at elevated temperatures to reduce outgassing to acceptable levels. Nevertheless, all foamed plastics used in the upper stage of the launch vehicle shall comply with the outgassing requirements specified in 4.1.3 of this appendix.

4.3.3 Special Considerations

Foamed plastics shall not be used for metal skin reinforcement nor as a core material in sandwich structural components.

Polyurethane foam material shall not come into contact with organic chemicals, including esters, ketones, and chlorinated and aromatic solvents.

4.4 Lubricants

4.4.1 Application

Lubrication shall be provided by greases, liquids, solid (dry) film lubricants, or a combination of either grease or liquid with solid film lubricants, soft metallic films, or lubricant-filled composite retainers (for ball bearings) for all contacting surfaces having relative motion.

4.4.2 Lubricant Selection

The selection and application of lubricants for launch vehicle systems and components shall be in accordance with NASA SP-8063 or other technically equivalent sources. Lubrication selection shall be made on the basis of the following considerations:

a. Coefficient of friction
b. Changes in lubricant property in storage or in a vacuum environment
c. Lubrication loss due to evaporation and migration
d. Operating environments
e. Creep properties
f. Viscosity versus temperature properties
g. Pressure coefficient of viscosity (in the case of ball bearings)
h. Outgassing characteristics
i. Compatibility with the contacting surfaces
j. Operating conditions, including rate of speed, load, and time duration

4.4.3 Outgassing

Lubricants shall comply with the outgassing requirements specified in para 4.1.3 of this appendix.

4.4.4 Special Considerations

a. Bonded solid film lubricants, such as molybdenum disulfide, is formulated using controlled particles in an inorganic or a thermosetting organic resin. The binder is hygroscopic and tends to soften. Provisions shall be made to protect lubricated parts against water condensation and excessive humidity.
b. Unless used in hermetically sealed devices, lubricating oils and greases shall not be used in direct exposure to hard vacuum.
c. Prior to application of a solid film lubricant, the substrates shall be protected by chemical processing, such as plating or anodizing.
d. Bonded solid lubricants shall be burnished to minimize particle generation. Burnishing removes loose particles and slightly compacts the coating.

4.5 Adhesives, Sealants, Coatings, and Encapsulants

4.5.1 Application

4.5.1.1 Adhesives

Silicone adhesives for general use shall be qualified to MIL-A-46146. Adhesives for structural applications shall be qualified in accordance with MIL-HDBK-83377.

Each adhesive shall be qualified for its application(s) and documented in an engineering report per MIL-A-83377. In addition, the processes used shall also be submitted for process approval.

4.5.1.2 Coatings

4.5.1.2.1 Conformal Coatings

Conformal coatings shall be in accordance with the requirements of IPC-CC-830, or MIL-I-46058C(7) and meet the application and thickness requirements of NASA-STD-8739.1 or J-STD-001, Class 3 with Space Addendum. Outgassing requirements for polymeric materials shall also be met.

4.5.1.2.2 Conformal Coatings Qualification

Each coating shall be qualified for its application (s) and the basis for qualification shall be documented. In addition, the processes associated with the coating shall be submitted for process approval.

4.5.1.3 Encapsulants

4.5.1.3.1 Application

Materials and processes used to encapsulate components and assemblies in plastic or elastomeric resins for electrical insulation, protection from environmental conditions, and protection from mechanical damage shall be qualified by component or assembly-level testing or past usage experience under equivalent or more severe thermomechanical stresses and radiation environments.

4.5.1.3.2 Processing Requirements

Processing requirements for encapsulation shall include as a minimum the following: surface preparation or cleaning, resin or elastomer preparation (including mix ratios), processing temperatures and times (including exothermic heat of reaction), shrinkage during cure, and rework.

4.5.2 Special Considerations

4.5.2.1 Glass Transition Temperature

Nonmetals can have up to two glass transition temperatures (Tg) in the allowable temperature range for the application. If there is a glass transition temperature in the relevant temperature range, then there shall be objective data that indicates that the Tg does not impact the intended application for the intended lifetime. This data may be included in the system qualification effort but shall be documented.

Silicone adhesives and sealants subjected to cryogenic temperatures shall have a secondary glass transition temperature below the minimum temperature of the application.

Adhesives intended for use at high temperatures (nominally >85°C) shall require PMPCA approval.

4.5.3 Prohibited Materials

Prohibited nonmetallic PMP shall include:

a. Asbestos-containing materials

b. Silicone grease as a thermal couplant except in sealed assemblies

c. Corrosive (acetic acid evolving) silicone sealants, adhesives, or coatings

d. Materials which can undergo reversion in their intended environment, including during manufacturing, testing, storage, and transportation

4.6 Composites

Composite materials are material systems made up of more than one constituent, usually a strong, stiff fiber and a relatively weak, soft binder. For the purposes of this document, composite materials are divided into three broad categories, these being polymer matrix composites, metal matrix composites, and ceramic matrix composites.

a. Polymer matrix composites consist of an organic polymer matrix as a binder combined with reinforcement (typically fibers) such as glass, graphite, and aramid.

b. Metal matrix composites are fiber, whisker, or particulate reinforced metals.

c. Ceramic matrix composites are fiber, whisker, or particulate reinforced ceramics and are classified into two material systems: oxide based and non-oxide based.

d. Ceramics

4.6.1 Application

Selection of materials and processes for composites shall consider all aspects of the intended application. These aspects include: service environment, system requirements, structural and functional requirements, electrical or dielectric requirements, serviceability, manufacturability, and reparability. The design and qualification of composite materials shall be in accordance with MIL-HDBK-17.

4.7 Ceramics

4.7.1 Application

Glasses and ceramics shall be limited in their use as structural elements due to their brittleness at ambient temperatures and lack of suitable nondestructive inspection techniques to ensure adequate strength and fracture resistance for specific stress and environmental conditions. The materials shall meet the applicable requirements of this appendix.

4.8 Sandwich Assemblies

A sandwich assembly is a specialized design that generates stiffness by the separation of two face skins by a core. The most common sandwich assembly has metallic honeycomb core and graphite-resin or metallic skins.

4.8.1 Application

4.8.1.1 Honeycomb Sandwich Assemblies

All sandwich assemblies shall be vented, and environments and operations shall be controlled to prevent ingress and entrapment of moisture. Sandwich assemblies shall be tested in accordance with SAE-AMS-STD-401. Aluminum honeycomb core sandwich assemblies shall use SAE-AMS-C-7438 perforated core.

4.8.1.2 Foam Core Sandwich Assemblies

Foam core structural sandwich assemblies shall be qualified for the intended application. Results of the qualification shall be documented.

4.8.1.3 Stiffened Sandwich Assemblies

Instead of foam or honeycomb, sandwich assemblies can be stiffened with a wide variety of geometric shapes, e.g., hat-stiffened panels. Stiffened panel assemblies shall be qualified for the intended application. Results of the qualification shall be documented.

5. Processes

5.1 General Requirements

5.1.1 Application

The contractor-developed manufacturing, installation, and inspection processes shall meet the requirements of this appendix.

5.1.2 Process Qualification

All processes shall be developed, qualified, and documented for the specific organization/facility performing the processing. Development shall include any supporting inspections (nondestructive or destructive), evaluations, and tests required for production as well as the information for the design that is necessary to obtain a repeatable product. Qualification shall be at an appropriate level of integration to ensure that qualification test results are relevant to the design. Process approval is based upon this documentation.

5.1.3 Process Requalification

Process requalification is required when the location and/or personnel and/or equipment have been changed.

5.1.4 Critical Processes

All critical processes shall be developed and qualified with respect to the relevant design and manufacturing environments. The qualification test program shall define the number of test specimens required to establish process repeatability and account for lot-to-lot material variability. Training and certification of personnel and machine qualification shall be required. The suitability of equipment, processes, and other support materials shall be demonstrated through qualification testing of test specimens that are representative of the materials and configuration of the production part.

5.1.5 New Processes

A process shall be considered a new technology if it is new or novel and if the system depends on this technology to meet operational requirements within acceptable production and operation costs. A new or novel process shall have at least one of the following attributes:

a. The process has not been successfully integrated into the contractor's product line.

b. The industrial base capable of designing, developing, producing, maintaining, and supporting the process is new or limited.

c. Process has not been validated and qualified for the intended design.

d. Resulting materials/products have not been characterized in a manufacturing environment.

All processes used in Category I application shall be developed and qualified with respect to the relevant design and manufacturing and manufacturing environments. The qualification test program shall define the Category I processes and how the associated critical characteristics of the process are verified for the relevant design application. Training and certification of personnel and machine qualification shall be required. The suitability of equipment, processes, and other support materials shall be demonstrated through qualification testing of test specimens that are representative of the materials and configuration of the production parts.

5.1.6 Special Considerations

5.1.6.1 Corrosion Considerations

The contractor processes utilized during manufacturing, testing, and installation operations shall prevent the introduction of contamination, corrosion, or corrosive elements.

5.1.6.2 Statistical Process Control

Process quality controls shall be maintained through a formal, documented, statistical process control program meeting the requirements of EIA-557.

5.1.6.3 Process Records

Process records that demonstrate successful application and completion of all required processes and related quality assurance requirements shall be maintained per program requirements. All certifications of compliance shall be supported by analyses or documentation showing successful processing or testing.

5.1.6.4 Cleaning Prior to Application

All processes involving adhesives, prepregs, sealants, coatings, and encapsulants shall require careful surface preparation to ensure adequate adhesion. Each qualified material shall have its associated cleaning, application, and usage process documented. Materials covered by this section shall be qualified with the specific surface preparation procedure described.

5.2 Adhesive Bonding

5.2.1 Application

Structural bonding shall conform to the guidelines of MIL-HDBK-83377.

5.2.2 Special Considerations

Bonding of structural components, except for high-temperature nozzle bonds, shall be tested under simulated service conditions using tag-end specimens or equivalent representative production specimens to demonstrate that the materials and processes selected provide the desired properties for the entire life of the component. When different thermal cycle testing temperature rate of change is used to accelerate the testing results, it shall be correlated to the expected rate of temperature change in service. As a minimum, all structural bonds shall require lap shear witness coupons made of the identical substrate processed concurrently using the same cleaning and cure methods.

5.3 Welding

5.3.1 Application

Fusion welding shall be performed in accordance with AWS D17.1.

Resistance welding of electronic circuit modules shall meet the requirements of AWS D17.2/D172M.

5.3.2 Special Considerations

5.3.2.1 Qualified Weld Procedure

The design and selection of parent materials and weld methods shall be based on consideration of the weldments, including adjacent heat-affected zones, as they affect operational capability of the parts concerned. Welding procedures and supplies shall be selected to provide the required weld quality, minimum weld energy input, and protection of heated metal from contaminants. The suitability of the equipment, processes, welding supplies, and supplementary treatments selected shall be demonstrated through qualification testing of welded specimens representing the materials and joint configuration of production parts. All welding of primary structural and pressure applications, including appropriate weld schedules and procedures, shall be documented and available for PMPCA review upon request.

5.3.2.2 Training, Certification, and Qualification

As a minimum requirement, welding operators shall be qualified in accordance with SAE-AMS-STD-1595. The welding shall be verified on each production lot to meet the initial qualification. The contractor shall provide the necessary training and qualification requirements to certify each operator and the applicable welding equipment for specific welding tasks required of critical launch vehicle hardware such as pressure vessel weldments, tubing weldments, and other primary structural components. The contractor training and certification requirements shall be subject to review and approval of the PMPCA.

5.3.2.3 Weld Filler Material

Weld rod or wire used as filler metal on structural parts shall be fully certified and documented for composition, type, heat number, manufacturer, supplier, etc., as required to provide positive traceability to the end use item. In addition, qualitative analysis and nondestructive testing shall be conducted on segments of each filler rod or wire as necessary to assure that the correct filler metal is used on each critical welding task. Quantitative analyses of weld filler metal on a lot-by-lot basis will be considered acceptable, provided that each structural weldment is subjected to simulated service testing or proof loading prior to acceptance.

5.3.2.4 Weld Rework

Weld rework shall be minimized by discriminating selection of acceptable methods, procedures, and specifications developed by the contractor. Weld rework is limited to the rework of welding defects in a production weld as revealed by inspection. Weld rework does not include the correction of dimensional deficiencies by weld buildup or “buttering” of parts in areas where the design did not provide for a welded joint. All weld rework shall be fully documented. Documentation as a minimum shall include weld procedures and schedules, location of the rework, nature of the problem, and appropriate inspection and qualification requirements for acceptance. The quality of reworked welds shall be confirmed by 100% inspection of both surface and subsurface, using visual, dimensional, and nondestructive techniques. Rework of welds in high-performance or critical parts shall not be permitted.

5.4 Brazing

5.4.1 Application

Metals not covered by AWS-C3.4, AWS-C3.5, AWS-C3.6, and AWS-C3.7 shall not be brazed. Resistance brazing shall meet the requirements of AWS-C3.9. Fusion welding or other operations involving high temperatures that may affect the brazed joint shall be prohibited in the vicinity of brazed joints. Brazed joints shall be designed for shear loading and shall not be used to provide strength in tension for structural parts. Allowable shear strength and design limitations shall conform to those recommended in MIL-HDBK-5(J).

5.4.2 Prohibited Materials

a. All metals not listed in AWS-C3.4, AWS-C3.5, AWS-C3.6, and AWS-C3 for resistance and dip brazing

b. Cadmium and zinc braze fillers not meeting the prohibited materials requirements of this document

5.5 Fastener Installation

5.5.1 Application

The installation of mechanical fasteners and associated parts, including cleaning prior to installation and application of protective finishes, shall meet the requirements of NASA-STD-6012 or MIL-STD- 403(C) as appropriate.

5.5.2 Special Considerations

5.5.2.1 Lubrication

Lubrication on fasteners, corrosion inhibiting or locking materials shall meet the outgassing requirements specified in paragraph 4.1.3 of this appendix. Noncompliant materials shall be removed prior to installation.

5.5.2.2 Dissimilar Metals

Fasteners installed in dissimilar metals shall meet the requirements of MIL-STD-889.

5.5.2.3 Outgassing

Anaerobic curing agents shall pass the outgassing requirements of this appendix.

5.5.3 Prohibited PMP

Fasteners with prohibited finishes such as zinc and/or cadmium platings/coatings shall not be used on spaceflight hardware nor in thermal vacuum chambers.

5.6 Forming and Straightening

5.6.1 Application

Forming and straightening operations performed on sheet metal, plate extrusions, and forgings shall be limited to processes which:

a. Do not result in detrimental residual stresses or losses in mechanical properties on structurally critical parts

b. Do not exceed the minimum bend radii for the material/condition combination

c. Do not lead to stress corrosion sensitivity of the parts

Shot peen forming is permissible. The contractor shall maintain adequate controls and supportive data that substantiates the forming and straightening processes being employed to meet the foregoing requirements.

5.7 Soldering and Solderability

5.7.1 Application

Soldering of piece parts to printed wiring boards shall be performed in accordance with the requirements of NASA-STD-8739.2 and NASA-STD-8739.3 or J-STD-001, Class 3 with the Space Addendum.

5.7.2 Solderability

All electronic piece parts that require soldering shall be demonstrated to be solderable or tinned (solder coated) prior to use. All piece parts with gold-plated leads, terminations, terminals, or other surfaces that require soldering shall be tinned (solder coated) to conform to the requirements of NASA-STD-8739.2 and NASA-STD-8739.3 or J-STD-001 with Space Addendum.

5.8 Heat Treating

5.8.1 Application

Metals and their alloys may be heat treated to accomplish various objectives. Specific thermal cycles can improve mechanical properties, improve corrosion resistance, reduce internal stresses, reduce harmful gases, improve machining properties, and/or optimize electrical, magnetic, and fabrication properties.

5.8.2 Heat Treating of Iron-Base Alloys

Thermal cycling strengthens carbon and alloy steels by means of hardening and tempering. Hardening, quench rate, and tempering temperatures for steels of various carbon contents shall be in accordance with SAE-AMS-H-6875 or SAE-AMS 2759.

5.8.3 Precipitation Hardening

Mechanical properties of some aluminum, magnesium, titanium, nickel alloys, beryllium-copper, and precipitation-hardening stainless steels can be improved by precipitation hardening. Precipitation hardening consists of solution treatment, quench, and precipitation at moderate temperatures. The precipitation hardening requirements for specific alloys and conditions are discussed under the corresponding material sections for aluminum alloys, heat-resistant alloys, precipitation-hardened stainless steels, and titanium alloys as appropriate.

5.8.4 Stress Relief

Materials that have been severely formed, welded, brazed or machined may contain residual stresses that can cause warping and instability. These internal stresses are eliminated by subsequent high-temperature heat treatment or reduced by stress-relieving at lower temperatures.

5.8.5 Other Heat-Treating Processes

Electrical and magnetic alloys can be thermally treated to tailor specific electrical, magnetic, and fabrication properties.

Electropolishing and plating processes are a source of hydrogen gas, which can degrade the performance of some materials. An elevated temperature bake shall be performed to reduce the quantity of hydrogen in susceptible alloys.

5.9 Plating and Chemical Finishing

5.9.1 Application

Metal plating and organic finishes for metallic materials are used to meet various engineering design requirements, including corrosion protection, electrical conductivity, high reflectivity, mechanical abrasion resistance, solderability, thermal control, or cosmetic appearance. The selection of the optimal metal plating or chemical finish for a part shall meet requirements of the specific application, environment, or design. Metal finishes shall be applied after all basic metal heat treatments and mechanical operations such as machining, brazing, welding, forming, and impregnating have been completed.

5.9.1.1 Corrosion Protection

Anodic or chemical conversion finishes such as Iridite® or chem film shall be utilized to provide corrosion protection for aluminum, magnesium, or stainless steels. Chromate coatings offer good humidity protection for aluminum and magnesium. For corrosion protection in hostile environments such as industrial, gaseous, or salt atmospheres, anodic finishes shall be applied.

5.9.1.2 Galvanic Protection

Metallic finishes shall be used to improve metal properties and provide dissimilar metal protection from galvanic corrosion. The plated metal shall be selected to minimize the difference in electromotive forces between the basis metal and the plated metal in the galvanic series in accordance with MIL-STD-889.

5.9.1.3 Wear and Abrasion Resistance

Certain plating, including nickel, electroless nickel, rhodium, and some anodic coatings, offer wear and abrasion resistant coatings.

5.9.1.4 Solderability

Tin alloy plating finishes provide solderability but are soft and malleable. Pure tin coatings (> 97%Sn) is reliability suspect due to the potential for formation of tin whiskers.

5.9.1.5 Other Applications

Black oxide chemical finishes for ferrous alloys, copper, and copper alloys are used to decrease light reflection and provide limited corrosion resistance.

Phosphate coatings may be used to precondition ferrous surfaces for improved adhesion of organic coatings or solid-film lubricant.

6. PMP Listing

6.1 Approved Mechanical Piece Parts

6.1.1 Screws

Specification	Part Number	Description	Limitations
NASM565	AN565*C*	SET SCREW, HEXAGON AND FLUTED SOCKET, HEADLESS	ONLY CORROSION-RESISTANT STEEL SET SCREWS ARE ACCEPTABLE.
NASM16995	MS16995-*	SCREW, CAP, SOCKET HEAD-HEXAGON, CORROSION-RESISTANT STEEL, UNC-3A	PASSIVATION IS THE ONLY ACCEPTABLE FINISH.
NASM16996	MS16996-*	SCREW, CAP, SOCKET HEAD-HEXAGON, CORROSION-RESISTANT STEEL, UNF-3A	PASSIVATION IS THE ONLY ACCEPTABLE FINISH.
NASM24693	MS24693-C*	SCREW, MACHINE, FLAT COUNTERSUNK HEAD, 100°, CROSS RECESSED, UNC-2A AND UNF-2A	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISH IS PASSIVATION.
NASM51021	MS51021-*	SETSCREW, HEXAGON SOCKET, CUP POINT, CORROSION-RESISTING STEEL, PASSIVATED, UNC-3A, PLAIN AND SELF-LOCKING	
MS51957	MS51957-*	SCREW, MACHINE, PAN HEAD, CROSS-RECESSED, CORROSION-RESISTANT STEEL, UNC-2A	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM51958	MS51958-*	SCREW, MACHINE, PAN HEAD, CROSS-RECESSED, CORROSION-RESISTANT STEEL, UNF-2A	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM565	AN565*C*	SETSCREW, HEXAGON AND FLUTED SOCKET, HEADLESS	ONLY CORROSION-RESISTANT SET SCREWS ARE ACCEPTABLE.
NASM16995	MS16995-*	SCREW, CAP, SOCKET HEAD-HEXAGON, CORROSION-RESISTANT STEEL, UNC-3A	
NASM16996	MS16996-*	SCREW, CAP, SOCKET HEAD-HEXAGON, CORROSION-RESISTANT STEEL, UNF-3A	
NASM24693	MS24693-C*	SCREW, MACHINE, FLAT COUNTERSUNK HEAD, 100°, CROSS-RECESSED, UNC-2A AND UNF-2A	
NASM51021	MS51021-*	SETSCREW, HEXAGON SOCKET, CUP POINT, CORROSION-RESISTANT STEEL, PASSIVATED, UNC-3A, PLAIN AND SELF-LOCKING	REPLACEMENT DOCUMENT FOR MS51021, PART NUMBERS REMAIN AS MS51021*.
NASM51958	MS51958-*	SCREW, MACHINE PAN-HEAD, CROSS-RECESSED, CORROSION-RESISTANT STEEL, UNF-2A	
NAS662	NAS662C*	SCREW, MACHINE, FLATHEAD 100° PLAIN AND SELF-LOCKING	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

Specification	Part Number	Description	Limitations
NAS673 THROUGH NAS678	NAS673V** THROUGH NAS678V**	BOLT, CLOSE TOLERANCE, HEXAGON HEAD, TITANIUM, 0.190 TO 0.500	UNCOATED TITANIUM FASTENERS, DRILLED OR UNDRILLED HEADS AND SHANKS
NASM21209	MS21209*	INSERT, SCREW THREAD, COARSE AND FINE, SCREW LOCKING, HELICAL COIL, CRES	ONLY UNCOATED OR DRY FILM LUBRICATED FINISHES ARE ACCEPTABLE.
NAS1081	NAS1081C*	SETSCREW, SELF-LOCKING	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT SEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS1101	NAS1101E*, NAS1101V*	SCREW, MACHINE-FLAT FILLISTER HEAD, FULL THREAD, OFFSET CRUCIFORM	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED (E) AND UNCOATED TITANIUM FASTENERS (V) ARE ACCEPTABLE.
NAS1102	NAS1102E*, NAS1102V*	SCREW, MACHINE, FLAT 100° HEAD, FULL THREAD, TORQ-SET®	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED (E) AND UNCOATED TITANIUM FASTENERS (V) ARE ACCEPTABLE.
NAS1131 THROUGH NAS1138	NAS1131E* THROUGH NAS1138E*	SCREW, MACHINE-PAN HEAD, CLOSE TOL, SHORT THD, OFFSET CRUCIFORM	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS1191	NAS1191E**	SCREW, SELF-LOCKING, FLAT FILLISTER HEAD, FULL THREAD	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS1218	NAS1218-04E*, NAS1218-06E*, NAS1218-08E*	BOLT, PAN HEAD, SELF-LOCKING OPTIONAL	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL AND ARE PASSIVATED ARE ACCEPTABLE.
NAS1271 THROUGH NAS1280	NAS1271-* THROUGH NAS1280-*	BOLT, TWELVE POINT, EXTERNAL WRENCHING, TITANIUM ALLOY	
NAS1351	NAS1351C* AND NAS1351N*	SCREW, CAP, SOCKET HEAD, UNDRILLED AND DRILLED, PLAIN AND SELF-LOCKING, ALLOY STEEL, CORROSION-RESISTANT STEEL AND HEAT-RESISTANT STEEL, UNRF-3A	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT OR HEAT-RESISTANT STEEL ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISH IS PASSIVATION.
NAS1352	NAS1352C* AND NAS1352N*	SCREW, CAP, SOCKET HEAD, UNDRILLED AND DRILLED, PLAIN AND SELF-LOCKING, ALLOY STEEL, CORROSION-RESISTANT STEEL AND HEAT-RESISTANT STEEL, UNRC-3A AND UNRC-2A	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT OR HEAT-RESISTANT STEEL ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISH IS PASSIVATION.
NAS1578	NAS1578C*	BOLT, FLAT PAN HEAD	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL AND ARE PASSIVATED ARE ACCEPTABLE.
NAS1635	NAS1635-*-*	SCREW, MACHINE – PAN HEAD, CROSS-RECESSED, FULL THREAD	ONLY FASTENERS PASSIVATED ARE ACCEPTABLE.
NAS1802	NAS1802*	SCREW, HEX HEAD, CRUCIFORM RECESS, FULL THREAD, A286 CRES, 160,000 PSI TENSILE	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

Specification	Part Number	Description	Limitations
NAS6303 THROUGH NAS6320	NAS6303*U* THROUGH NAS6320*U*	BOLT, TENSION, HEX HEAD, CLOSE TOLERANCE, A286 CRES, SHORT THREAD, REDUCED MAJOR THREAD DIA., SELF-LOCKING AND NONLOCKING, 160 KSI FTU	ONLY FASTENERS THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS6403 THROUGH NAS6420	NAS6403*U* THROUGH NAS6420*U*	BOLT, TENSION, HEX HEAD, CLOSE TOLERANCE, 6 AL-4V TITANIUM ALLOY, SHORT THREAD, REDUCED MAJOR THREAD DIA., SELF-LOCKING AND NONLOCKING, 160 KSI FTU	ONLY FASTENERS THAT ARE NOT PLATED ARE ACCEPTABLE.
NAS6703 THROUGH NAS6720	NAS6703*U* THROUGH NAS6720*U*	BOLT, HEX HEAD, CLOSE TOLERANCE, A286 CRES, LONG THREADS, SELF-LOCKING AND NONLOCKING	THE ONLY ACCEPTABLE FINISH IS PASSIVATION PER QQ-P-35.
NAS6803 THROUGH NAS6820	NAS6803*U* THROUGH NAS6820*U*	BOLT, HEX HEAD, CLOSE TOLERANCE, 6AL-4V TITANIUM ALLOY, LONG THREAD, SELF-LOCKING AND NON LOCKING	ONLY FASTENERS THAT ARE NOT PLATED ARE ACCEPTABLE.
NAS8100 THROUGH NAS8106	NAS8100*U* THROUGH NAS8106*U*	SCREW, PAN HEAD, CRUCIFORM RECESS, A-286 CRES, FULL THREAD, SELF-LOCKING AND NONLOCKING	THE ONLY ACCEPTABLE FINISH IS PASSIVATION.
NA0274	NA0274-******	SCREW, CAP, SOCKET HEAD, FULL THREAD, 300 SERIES, CRES, 500 MPA FTU, METRIC	
NA0069	NA0069-******, NA0069H******	SCREW, CAP, HEXAGON SOCKET HEAD, FULL THREAD, A-286 CRES, 1100 MPA METRIC	

6.1.2 Nuts

Specification	Part Number	Description	Limitations
AS9361 [CORROSION- AND HEAT-RESISTANT STEEL IN ACCORDANCE WITH AMS 5732 OR AMS 5737. PARTS ARE CLEANED IN 1 VOLUME OF NITRIC ACID AND 9 VOLUMES OF WATER AT ROOM TEMPERATURE]	MS9361-**	NUT, PLAIN, HEXAGON, CHECK, UNS S66286, 130 KSI MIN.	
SAE-AS9362	MS9362-**	NUT, PLAIN, HEXAGON, CHECK, A-286, SILVER-PLATED, MIL-S-8879	
NASM21043	MS21043-*	NUT, SELF-LOCKING, 800ºF, REDUCED HEXAGON, REDUCED HEIGHT, RING BASE, CORROSION-RESISTANT STEEL	
NASM21045	MS21045C*	NUT, SELF-LOCKING, HEXAGON-REGULAR HEIGHT, 450ºF, 125 KSI FTU	ONLY NUTS MADE OUT OF CORROSION-RESISTANT STAINLESS STEEL ARE ACCEPTABLE.

Specification	Part Number	Description	Limitations
NASM21060	MS21060*	NUT, SELF-LOCKING, PLATE, TWO LUG, FLOATING, LOW HEIGHT, CRES, 125 KSI FTU, 450ºF AND 800ºF	
NASM21070	MS21070*	NUT, SELF-LOCKING, PLATE, TWO LUG, REDUCED RIVET SPACING, LOW HEIGHT, CRES, 125 KSI FTU, 450ºF AND 800ºF	
NASM21076	MS21076*	NUT, SELF-LOCKING, PLATE, TWO LUG, FLOATING, REDUCED RIVET SPACING, LOW HEIGHT, CRES 125 KSI FTU, 450ºF AND 800ºF	
MS27130	MS27130-CR*	NUT, PLAIN, BLIND RIVET-FLAT AND COUNTERSUNK HEAD, OPEN END	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISH IS PASSIVATION.
MS25082	MS25082-C*	NUT, PLAIN, HEXAGON, ELECTRICAL, THIN	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
MS35649	MS35649-204, 224, -2254, -2314, -2384, -244, -264, -284	NUT, PLAIN HEXAGON, MACHINE SCREW, UNC-2B	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
MS35650	MS35650-314, -324, -344, -364, -384, -304, -3254, -3314, -3384, -3394, -3404	NUT, PLAIN, HEXAGON, MACHINE SCREW, UNF-2B	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM21070	MS21070*	NUT, SELF-LOCKING, PLATE, TWO LUG, REDUCED RIVET SPACING, LOW HEIGHT, CRES, 125 KSI FTU, 450ºF AND 800ºF	
NASM21076	MS21076*	NUT, SELF-LOCKING, PLATE, TWO LUG, FLOATING, REDUCED RIVET SPACING, LOW HEIGHT, CRES, 125 KSI FTU, 450ºF AND 800ºF	
NAS671	NAS671C*	NUT, PLAIN, HEXAGON, SMALL PATTERN, NONSTRUCTURAL	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM45938/1	MS45938/1-*C	NUT, PLAIN, CLINCH (SELF-CLINCHING, ROUND)	PARTS ARE MADE FROM CORROSION-RESISTANT STEEL AND ARE PASSIVATED.
NAS1068	NAS1068C* AND RC*	NUT, SELF-LOCKING PLATE, TWO LUG, LOW HEIGHT, C-BORED, FLOATING	ONLY FASTENERS MADE OUT OF A286 CORROSION-RESISTANT STEEL ARE ACCEPTABLE.

Specification	Part Number	Description	Limitations
NAS1291	NAS1291C*, NAS1291C*M	NUT, SELF-LOCKING, HEXAGON, LOW HEIGHT, LIGHT WEIGHT	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISHES ARE SILVER PLATING AND DRY FILM LUBRICATION. SILVER-PLATED PART SHALL NOT BE IN CONTACT WITH TITANIUM.
NAS1329	NAS1329N*	NUT, BLIND RIVET, FLATHEAD, INTERNAL THREAD, NONLOCKING (FREE RUNNING) AND SELF-LOCKING (PREVAILING TORQUE)	ONLY FASTENERS MADE OUT OF CRES 316 THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS1330	NAS1330N**	NUT, BLIND RIVET, COUNTERSUNK HEAD, INTERNAL THD, NONLOCKING (FREE-RUNNING) AND SELF-LOCKING (PREVAILING TORQUE)	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

6.1.3 Nut Plates

Specification	Part Number	Description	Limitations
CB6009 CLICK BOND [CR = QQ-P-35 PASSIVATED A-286 BASEPLATE - = QQ-P-35 PASSIVATED A-286 NUT WITH MIL-L-46010, TY1 DRY FILM LUBE]	CB6009CR*-*	NUT PLATE, TWO LUG, ADHESIVE BONDED	

6.1.4 Washers

Specification	Part Number	Description	Limitations
AN960	AN960C*	WASHER FLAT	ONLY WASHERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
MIL-W-12133/4	M12133/4-***	WASHER, SPRING TENSION, WAVE, CRES 302	ONLY FASTENERS THAT ARE PASSIVATED ARE ACCEPTABLE.
MS9768	MS9768-**	WASHER, FLAT, CRES AMS 5525 OR AMS 5737, COUNTERSUNK	
NASM15795	MS15795-8*	WASHER, FLAT METAL, ROUND, GENERAL PURPOSE	PASSIVATION IS THE ONLY ACCEPTABLE FINISH.
MS51848	MS51848-49	WASHER, LOCK, HELICAL SPRING, HI-COLLAR	ONLY WASHERS MADE OUT OF 300 SERIES CRES THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM15795	MS15795-8*	WASHER, FLAT-METAL, ROUND, GENERAL PURPOSE	ONLY FASTENERS MADE OUT OF STAINLESS STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM35338	MS35338-134 THROUGH -152	WASHER, LOCK, SPRING, HELICAL, REGULAR (MEDIUM) SERIES	ONLY STAINLESS-STEEL PARTS THAT ARE PASSIVATED ARE ACCEPTABLE.

Specification	Part Number	Description	Limitations
NAS549	NAS549G*	WASHER, NONMETALLIC, ELECTRICAL INSULATING	ONLY FASTENERS MADE OUT OF EPOXY GLASS (MIL-I-24768/3) ARE ACCEPTABLE.
NAS620	NAS620C*	WASHER, FLAT, REDUCED OUTSIDE DIAMETER	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NAS1149	NAS1149C*R, NAS1149E*R, NAS1149V*H, NAS1149T*H	WASHER, FLAT	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE. ONLY FASTENERS MADE OUT OF TI 6AL-4V THAT ARE UNFINISHED ARE ACCEPTABLE.
NAS1587	NAS1587-*	WASHER, PLAIN AND CSK, 1200ºF	MADE OUT OF PASSIVATED CRES
MS51496	MS51496P61 THROUGH P87	WASHER, FLAT-NARROW SERIES	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

6.1.5 Inserts

Specification	Part Number	Description	Limitations
MS51830	MS51830CA*, MS51830CA*L	INSERT, SCREW-THREAD, LOCKED IN, KEY-LOCKED, MINIATURE AND LIGHTWEIGHT	ONLY INSERTS MADE OUT OF A286 CRES ARE ACCEPTABLE.
NASM122076 THROUGH NASM122115	MS122076 THROUGH MS122115	INSERT, CRES, HELICAL COIL, COARSE THREAD, 1 DIA. NOMINAL LENGTH	
NASM122116 THROUGH NASM122155	MS122116 THROUGH MS122155	INSERT, CRES, HELICAL COIL, COARSE THREAD, 1-1/2 DIA. NOMINAL LENGTH	
NASM122156 THROUGH NASM122195	MS122175 THROUGH MS122195	INSERT, CRES, HELICAL COIL, COARSE THREAD, 2 DIA. NOMINAL LENGTH	
NASM124691 THROUGH NASM124730	MS124691 THROUGH MS124730	INSERT, CRES, HELICAL COIL, FINE THREAD 1-1/2 DIA.NOMINAL LENGTH	
NASM124731 THROUGH NASM124770	MS124731 THROUGH MS124770	INSERT, CRES, HELICAL COIL, FINE THREAD, 2-DIA. NOMINAL LENGTH	
NASM21209	MS21209*	INSERT, SCREW THREAD, COARSE AND FINE, SCREW LOCKING, HELICAL COIL, CRES	ONLY UNCOATED OR DRY FILM LUBRICATED FINISHES ARE ACCEPTABLE.
NASM122076 THROUGH NASM122115	MS122076 THROUGH MS122115	INSERT, CRES, HELICAL COIL, COARSE THREAD, 1 DIA. NOMINAL LENGTH	
NASM122116 THROUGH NASM122155	MS122116 THROUGH MS122155	INSERT, CRES, HELICAL COIL, COARSE THREAD, 1-1/2 DIA. NOMINAL LENGTH	
NASM122156 THROUGH NASM122195	MS122156 THROUGH MS122195	INSERT, CRES, HELICAL COIL, COARSE THREAD, 2-DIA. NOMINAL LENGTH	

Specification	Part Number	Description	Limitations
NASM124691 THROUGH NASM124730	MS124691 THROUGH MS124730	INSERT, CRES, HELICAL COIL, FINE THREAD, 1-1/2-DIA. NOMINAL LENGTH	
NASM124731 THROUGH NASM124770	MS124731 THROUGH MS124770	INSERT, CRES, HELICAL COIL, FINE THREAD, 2-DIA. NOMINAL LENGTH	
NAS1130	NAS1130-*-*	INSERT, SCREW THREAD, HELICAL COIL, FREE RUNNING AND SELF-LOCKING, TANGLESS	ONLY UNCOATED OR DRY FILM LUBRICATED FINISHES ARE ACCEPTABLE.
NAS1395	NAS1395C* AND NAS1395CA*	INSERT-THREADED METAL, HEAVY-DUTY, SELF-LOCKING, AND NONSELF-LOCKING	ONLY FASTENERS MADE OUT OF CORROSION-RESISTANT OR HEAT-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
SL601 SHUR-LOK [C = CRES 303 PER ASTM A 582 WITH PASSIVATION. N INDICATES NO NYLON THREAD LOCK PER L-P-410.]	SL601-*N*C SL601-*-*C	INSERT, BLIND THREADED	
SL602 SHUR-LOK [C = CRES 303 PER ASTM A 582, WITH PASSIVATION. N INDICATES NO NYLON THREAD LOCK PER L-P-410]	SL602-*N*C SL602-*-*C	INSERT, THROUGH THREADED	.
SL606 SHUR-LOK [C = CRES 303 PER ASTM A 582 WITH PASSIVATION FOR NUT AND HOUSING. CAP MADE OUT OF AL 6061-0 PER QQ-A-250/11 WHICH IS ANODIZED PER MIL-8625 TYPE 1 CLASS OPTIONAL OR CHEM FILM PER MIL-C-5541 CLASS 3 OR 1A. N INDICATES NO NYLON THREAD LOCK PER L-P-410.]	SL606-*N*C SL606-*-*C	INSERT, BLIND THREADED, FLOATING NUT	
SL644 SHUR-LOK [C = CRES 303 PER ASTM A581 OR ASTM A582 WITH PASSIVATION.]	SL644C*-*	INSERT, BLIND THREAD, LIGHTWEIGHT	
SL6288 SHUR-LOK [A= AL 2024-T851 PER AMS-QQ-A-225/6 WITH ANODIZE PER MIL-A-8625.]	SL6288A*-*	INSERT, LIGHTWEIGHT, NONLOCKING, SHUR-TAB	

6.1.6 Rivets

Specification	Part Number	Description	Limitations
NASM20426	MS20426AD-* MS20426E-* MS20426T-*	RIVET, SOLID, COUNTERSUNK 100º PRECISION HEAD, ALUMINUM AND TITANIUM COLUMBIUM ALLOY	ONLY RIVETS MADE OUT OF 2117-T4 “AD,” 7050-T73 “E,” AND TITANIUM COLUMBIUM ALLOY 45CB “T” ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISHES FOR ALUMINUM ARE MIL-C-5541 CLASS 1A AND MIL-A-8625 TYPE II CLASS 1.
NASM20470	MS20470-AD-* MS20470-E-*	RIVET, SOLID, UNIVERSAL HEAD, ALUMINUM ALLOY AND TITANIUM COLUMBIUM ALLOY	ONLY RIVETS MADE OUT OF 2117-T4 “AD” OR 7050-T73 “E” ARE ACCEPTABLE. THE ONLY ACCEPTABLE FINISH IS MIL-C-5541 CLASS 1A OR MIL-A-8625 TYPE II CLASS 1.
NAS1919	NAS1919B**-**FC	RIVET, BLIND, GENERAL PURPOSE, BULBED, PROTRUDING HEAD, MECHANICALLY LOCKED-SPINDLE	ONLY MIL-C-5541 CLASS 1 CONVERSION COATED RIVETS ARE ACCEPTABLE.
NAS1921	NAS1921B**-**FC	RIVET, BLIND, GENERAL PURPOSE, BULBED, 100º FLUSH HEAD, MECHANICALLY LOCKED-SPINDLE	ONLY MIL-C-5541 CLASS 1 CONVERSION-COATED RIVETS ARE ACCEPTABLE.

6.1.7 Pins

Specification	Part Number	Description	Limitations
MIL-P-21143/2	M21143/2-*	PIN, STRAIGHT, HEADLESS (DOWEL) (0.0002 UNDER SIZE), CRES 303	
NASM16555	MS16555-6**	PIN, STRAIGHT, HEADLESS (DOWEL) (0.0002 OVER NOMINAL SIZE)	ONLY STAINLESS-STEEL PARTS THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM51987	MS51987-369 THROUGH -455	PIN, SPRING-TUBULAR, COILED, LIGHT DUTY	ONLY PINS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM16556	MS16556-6** THROUGH -7**	PIN, STRAIGHT, HEADLESS (DOWEL) (.001 OVER NOMINAL SIZE)	ONLY PINS MADE OUT OF STAINLESS STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.
NASM16562	MS16562-189 THROUGH -282	PIN, SPRING, TUBULAR, SLOTTED	ONLY FASTENERS MADE OUT CORROSION-RESISTANT STEEL ARE ACCEPTABLE.
NASM24665	MS24665-300, -302, -372, -376 & -437	PIN COTTER (SPLIT)	PARTS ARE MADE FROM CORROSION-RESISTANT STEEL AND ARE PASSIVATED.
NASM51987	MS51987-369 THROUGH -455	PIN, SPRING,TUBULAR, COILED, LIGHT DUTY	ONLY PINS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

6.1.8 Mount Cable Ties

Specification	Part Number	Description	Limitations
CB3019 CLICK BOND [AA = 5052 OR 6061 ALUMINUM ALLOY BASE ANODIZED PER MIL-A-8625 TYPE 1 NB = NYLON, BLACK, STABILIZED MOUNT MATERIAL]	CB3019AA*NB*	MOUNT, CABLE TIE	
CB4019 CLICK BOND [E = GLASS/EPOXY 350°F, BASE C = CARBON/EPOXY 350°F, BASE T = TEFZEL MOUNT MATERIAL NB = NYLON, BLACK, STABILIZED MOUNT MATERIAL]	CB4019E*T*, CB4019C*T*, CB4019C*NB*	MOUNT, CABLE TIE, COMPOSITE BASE	
CB4021 CLICK BOND [E = GLASS/EPOXY 350°F, BASE T = TEFZEL MOUNT MATERIAL]	CB4021E*T*	MOUNT, CABLE TIE, STANDOFF, COMPOSITE	
CB9120 CLICK BOND [V = GLASS/ THERMOPLASTIC, 350°F]	CB9120V*	MOUNT, CABLE TIE, ANCHOR	

6.1.9 Studs

Specification	Part Number	Description	Limitations
CB4000 CLICK BOND [C = CARBON/EPOXY 350°F, BASE, G = GLASS/EPOXY 250°F, BASE T = TITANIUM 6AL-4 V STUD, CR = 300 SERIES STAINLESS STUD AND CRA = A-286 CRES]	CB4000G*T* CB4000G*CR* CB4000G*CRA* CB4000C*T* CB4000C*CR* CB4000C*CRA*	STUD, COMPOSITE BASE, ADHESIVE BONDED	
CB9007 CLICK BOND [T = 6AL-4V TITANIUM]	CB9007T*	STUD, SMALL BASE, TRIMMED	
CB9015 CLICK BOND [AC = 7075-T73 ALUMINUM, MIL-C-5541, CLASS 3, AA = 7075-T73 ALUMINUM, MIL-A-8625]	CB9015AC* CB9015AA*	STUD, SMALL BASE, THREADED	

6.1.10 Standoffs

Specification	Part Number	Description	Limitations
CB4001 CLICK BOND [C = CARBON/EPOXY 350°F, BASE G = GLASS/EPOXY 250°F, BASE T = TITANIUM 6AL-4V STUD CR = 300 SERIES STAINLESS STUD AND CRA = A-286 CRES]	CB4001G*T*, CB4001G*CR*, CB4001G*CRA*, CB4001C*T*, CB4001C*CR*, CB4001C*CRA*	STANDOFF, LOCKING THREAD, COMPOSITE BASE	
CB9016 CLICK BOND [AC = 7075-T73 ALUMINUM, MIL-C-5541, CLASS 3, AA = 7075-T73 ALUMINUM, MIL-A-8625]	CB9016AC* CB9016AA*	STANDOFF, SMALL BASE, THREADED	

6.1.11 Connector Mounting Hardware

Specification	Part Number	Description	Limitations
MIL-DTL-38999/28 [PART IS MADE OUT OF ALUMINUM AND IS ELECTROLESS NICKEL PLATED]	D38999/28-**G	CONNECTORS, ELECTRICAL, CIRCULAR, NUT, HEXAGON, CONNECTOR MOUNTING, SERIES III AND IV, METRIC	
MIL-PRF-83513/5	M83513/05-*	CONNECTORS, ELECTRICAL, RECTANGULAR, MICROMINIATURE, MOUNTING HARDWARE	

6.1.12 Wire

Specification	Part Number	Description	Limitations
NASM20995	MS20995C15, C20, C32, C41, C47, C91, NC20, NC32, NC40, NC51 AND NC91	WIRE, SAFETY OR LOCK	

6.1.13 Rods

Specification	Part Number	Description	Limitations
NAS1454	NAS1454C*-*	ROD, CONTINUOUS THREAD	ONLY RODS MADE OUT OF CORROSION-RESISTANT STEEL THAT ARE PASSIVATED ARE ACCEPTABLE.

6.1.14 Shim Rock

Specification	Part Number	Description	Limitations
AMS-DTL-22499	--	SHIM STOCK	APPROVED ALUMINUM, CRES, TITANIUM, AND POLYIMIDE

6.1.15 Terminals

Specification	Description
A-A-59126	TERMINALS, FEEDTHRU (INSULATED) AND TERMINALS, STUD (INSULATED AND NONINSULATED)

6.2 Approved Materials

6.2.1 Metallic Materials

6.2.1.1 Aluminum Alloys

Designation	Condition	Specification	Limitations
1000 Series	ALL	ASTM B209 AMS 4102 ASTM B211 ASTM B210	
3000 Series	ALL	ASTM B241 ASTM B209 ASTM B211 ASTM B221	
2024 Wrought Rod and Bar only	T851	ASTM B211	
2117	T4	QQ-A-430C	
2219	T6 T62 T81 T851 T87 T852	AMS-QQ-A-367A AMS-QQ-A-250/30 AMS-A-22771A	
5000 SERIES	ALL	ASTM B241 ASTM B221 AMS-QQ-A-250/6 AMS 4015/4016/4017 ASTM B209 AMS-QQ-A-250/9 MIL-C-7438	ALLOY 5456, 5083, AND 5086 APPROVED ONLY IN CONTROLLED TEMPERS (H111, H112, H116, H117, H323, H343) FOR RESISTANCE TO SCC. ALLOYS WITH MAGNESIUM MORE THAN 3% BY WEIGHT SHALL BE USED IN APPLICATIONS LOWER THAN 150°F.
6013	T4 T6	AMS 4216 AMS 4347	
6061	All	AMS 4025/4026/4027 AMS-QQ-A-225/8 AMS-QQ-A-200/8 AMS-A-22771A ASTM B308 ASTM B241 ASTM B209 ASTM B211 ASTM B221 AMS-QQ-A-250/11A AMS-QQ-A-367A	
6063	All	ASTM B241 ASTM B483 ASTMB210 AMS 4156 ASTM B221	
6351	T6	ASTM B241	
7049	T73	AMS-QQ-A-367A	

Designation	Condition	Specification	Limitations
7050	T73511	AMS 4341	
7075	T73 T7351 T73510 T73511 T7352	AMS-QQ-A-250/12 AMS-QQ-A-225/9 AMS-QQ-A-200/11 AMS-A-22771A AMS 4147 AMS-QQ-A-367A	
C355	T6	AMS 4215	
E357	T6	AMS4288	
A380	F	AMS 4291 ASTM B85	
A356	T6	ASTM B26	
A356 E357	T61	ASTM B108	

6.2.1.2 Copper and Copper Alloys

Designation	Condition	Specification	Limitations
CDA101 (UNS No. C10100) CDA102 (UNS No. C10200) OXYGEN FREE HIGH CONDUCTIVITY (OFHC) COPPER	ALL	ASTM B152 ASTM B170 ASTM B187 ASTM B272 ASTM F68	
CDA110 (UNS No. C11000) TOUGH PITCH	37% MAXIMUM COLD ROLLED	ASTM B152 ASTM B187 ASTM B272	
CDA170 (UNS No. C17000) BERYLLIUM COPPER	ALL	ASTM B194	
CDA172 (UNS No. C17200) BERYLLIUM COPPER	ALL	ASTM B194 ASTM B196 ASTM B197	
CDA230 (UNS No. C23000) RED BRASS	40% MAXIMUM COLD ROLLED	ASTM B36	
CDA510 (UNS No. C51000) PHOSPHOR BRONZE	37% MAXIMUM COLD ROLLED	ASTM B103 ASTM B139 ASTM B159	
COPPER WIRE	SOFT OR ANNEALED	ASTM B3	

6.2.1.3 Corrosion-resistant Steels, Passivated

Designation	Condition	Specification	Limitations
15-5-PH	H1000 AND ABOVE	AMS 5659	
17-7 PH	C CH900	AMS 5529 ASTM A313 ASTM A693	MATERIAL PROCURED PER AMS 5529 IN CONDITION C SHALL BE AGED TO CONDITION CH 900.
PH15-7MO	CH900	ASTM A693	
CUSTOM 450, 455	H1000 AND ABOVE	AMS 5936 ASTM A693 AMS 5617 AMS 5860 AMS 5578 AMS 5672	
301	ALL	AMS 5517 AMS 5518 AMS 5519	APPROVED FOR NONWELDING APPLICATIONS

Designation	Condition	Specification	Limitations
		AMS 5901 ASTM A666	
303	SOLUTION HEAT TREATED (ANNEALED)	AMS 5640 TYPE 1	
304L, 304	SOLUTION HEAT TREATED (ANNEALED)	AMS 5569 AMS 5647 ASTM A240 ASTM A666 AMS 5513	304 APPROVED FOR NONWELDING APPLICATIONS
316L, 316	SOLUTION HEAT TREATED (ANNEALED)	AMS 5653 ASTM A240 ASTM A666	316 APPROVED FOR NONWELDING APPLICATIONS
321	SOLUTION HEAT TREATED (ANNEALED)	AMS 5570 AMS 5645 ASTM A240 ASTM A666	
347	SOLUTION HEAT TREATED (ANNEALED)	AMS 5646 ASTM A240 ASTM A666	
440C	ALL	AMS-QQ-S-763 AMS 5618	APPROVED ONLY FOR BEARING BALLS
A286	ALL	AMS 5525 AMS 5731 AMS 5732 AMS 5734 AMS 5737	
302	SOLUTION HEAT TREATED (ANNEALED)	AMS 5516	APPROVED FOR NONWELDING APPLICATIONS
316	1/4 HARD	AMS 5907	APPROVED FOR NONWELDING APPLICATIONS
304	SOLUTION HEAT TREATED (ANNEALED) AND COLD ROLLED	AMS 5910	APPROVED FOR NONWELDING APPLICATIONS
304	FULL HARD	AMS 5913	APPROVED FOR NONWELDING APPLICATIONS

6.2.1.4 Nickel and Nickel Alloys

Designation	Condition	Specification	Limitations
MONEL K-500	ALL	QQ-N-286	
DUMET	ALL	AMS 7734	
HASTELLOY C	ALL	AMS 5530	
HASTELLOY X	ALL	AMS 5536 AMS 5587 AMS 5588 AMS 5754	
INCONEL 600	ALL	AMS 5580 AMS 5687 ASTM B168 ASTM B166 ASTM B564	

Designation	Condition	Specification	Limitations
INCONEL 625	ALL	AMS 5581 AMS 5666 AMS 5687	
INCONEL 718	ALL	AMS 5589 AMS 5590 AMS 5596 AMS 5597 AMS 5662 AMS 5664	
INCONEL X750	ALL	AMS 5582 AMS 5542 AMS 5598 AMS 5667 AMS 5698 AMS 5747 AMS 5668 AMS 5670 AMS 5671 AMS 5699	
NICKEL 200, 201	ALL	ASTM B160 ASTM B161 ASTM B162	
NICKEL 205	ALL	MIL-N-46025	
WASPALOY	ALL	AMS 5708	

6.2.1.5 Low Alloy Steel

Designation	Condition	Specification	Limitations
4130	MAX 180 KSI ULTIMATE TENSILE STRENGTH	AMS 6350 AMS 6351 AMS 6348 AMS 6370 AMS 6528 AMS 6345 AMS-T-6736A AMS-6758A	
4140	MAX 180 KSI ULTIMATE TENSILE STRENGTH	AMS 6395 AMS 6382 AMS6349 AMS 6529 AMS 6381 AMS 6390	
4340	MAX 180 KSI ULTIMATE TENSILE STRENGTH	AMS 6359 AMS 6415 AMS-S-5000A AMS 6414	

6.2.1.6 Magnesium Alloys

AZ31B	ALL	ASTM B107 AMS 4375 AMS 4376 AMS 4377	APPROVED ONLY FOR TENSILE STRESSES LOWER THAN STRESS-CORROSION THRESHOLD
ZK60A	ALL	ASTM B107 AMS 4352	APPROVED ONLY FOR TENSILE STRESSES LOWER THAN STRESS-CORROSION THRESHOLD

6.2.1.7 Titanium and Titanium Alloys

NOTE: Do not use halogenated materials in the processing.

Designation	Condition	Specification	Limitations
COMMERCIALLY PURE TITANIUM	ALL	MIL-T-9046J MIL-T-9047G AMS 4900 AMS 4901 AMS 4902 AMS 4941	
Ti-3Al-2.5V	ALL	AMS 4943 AMS 4944 AMS 2311 MIL-T-9046J MIL-T-9047G	
Ti-6Al-4V	ALL	MIL-T-9046J MIL-T-9047G AMS 4911 AMS 4928 AMS 4956 AMS 4967 ASTM B265 ASTM B348 AMS 6931	

6.2.1.8 Miscellaneous Metallic Materials

Designation	Condition	Specification	Limitations
BRAZE/SOLDER ALLOYS			
BRAZE ALLOY 82 AU/18NI NIORO	ALL	AMS 4787	
BRAZING ALLOY, SILVER BAg-8 (UNS P07720) BAg-8a (UNS P07723) BAg-19 (UNS P07925) Bag-23 (UNS P07850)	ALL	AWS A5.8 QQ-B-654A	FOR BRAZING FERROUS AND NONFERROUS METALS EXCEPT ALUMINUM AND MAGNESIUM ALLOYS
BRAZING ALLOYS, ALUMINUM-SILICON BAlSi-2 (UNS A94343) BAlSi-3 (UNS A94145) BAlSi-4 (UNS A94047)	ALL	AWS A5.8 QQ-B-655C	FOR BRAZING ALUMINUM ALLOYS ONLY
BRAZING ALLOYS, COPPER, COPPER-PHOSPHOROUS BCu-1 (UNS C14180) BCuP-3 (UNS C55281) BcuP-5 (UNS C55284)	ALL	AWS A5.8 QQ-B-650C	BCuP-3 AND BCuP-5 SHALL NOT BE USED FOR JOINING FERROUS ALLOYS OR FOR JOINING ALLOYS CONTAINING MORE THAN 10% NICKEL.
BRAZING SHEET (6951-4045) # 23 and 24	ALL	MIL-B-20148D	
SOLDERS Sn 63/Pb 37 Sn 62/Pb 36/Ag 02 Sn 60/Pb 40	ALL	J-STD-005 J-STD-006 QQ-S-571F	USE OF RA FLUX IS NOT ACCEPTABLE ON SPACECRAFT HARDWARE.
OTHER MISCELLANEOUS METALS/ ALLOYS			

Designation	Condition	Specification	Limitations
TUNGSTEN		ASTM B777 ASTM B760 MIL-T-21014D	
GOLD	ALL	AMS 7731 ASTM F72	
MAGNET ALNICO V, VI, VIII	ALL	MIL-M-46888	
MAGNET SAMARIUM COBALT	ALL	AMS 7510	
MP35N®	SOLUTION HEAT TREATED, COLD WORKED, COLD WORKED AND AGED	AMS5758 AMS5844 AMS5845	COLD-WORKED MATERIAL PER AMS 5844 SHALL BE AGED AFTER FABRICATION OF PART.
SHIM STOCK, VARIOUS METALS		AMS-DTL-22499	APPROVED ALUMINUM, CRES, TITANIUM
TANTALUM (UNS No. R05200, UNS No. R05400, UNS No. R05210)	COLD ROLLED/ ANNEALED	ASTM B365 ASTM B708 AMS 7849	

6.2.2 Nonmetallic Materials

6.2.2.1 Adhesives

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ABLEFILM 550K	0.31	0.04	125C/2H	ELECTRICALLY INSULATING AND THERMALLY CONDUCTIVE VERSION OF ABLEFILM 550
CV-1142-2	0.31	0.01	RT/7D	RTV SILICONE ONE-COMPONENT STAKING COMPOUND; BLACK (-1) OR TRANSLUCENT (-2)
CV-1142-1 SILICONE	0.23	0.01	RT/7D	ONE COMPONENT WHITE SEALANT, %WVR = 0.04
CV-2566	0.38	0.05	25C/7D OR 65C/4H	2-PART IRON OXIDE-FILLED SILICONE
DC 6-1104	0.13	0.04	RT/7D	CLEAR RTV SEALANT
DC 6-1125	0.17	0.01	RT/7D	WHITE ONE-PART SILICONE SEALANT
DC 93-500	0.19	0.04	RT/14H OR 60C/6H	RTV, 2-PART, CLEAR SILICONE ADHESIVE, 10/1 PBW
EA 9309NA	0.95	0.01	RT/7D	FLEXIBILIZED STRUCTURAL ADHESIVE 100/23 PBW
EA 9309.3 NA	0.89	0.01	RT/7D	SIMILAR TO EA 9309, BUT FILLED WITH 5 MIL GLASS BEADS 100/23 PBW
EA 956	0.69	0.02	RT/7D	UNFILLED, LOW-VISCOSITY EPOXY
FM 410-1	0.84	0.00	121C/3H	EPOXY FOAM ADHESIVE
FM 73	0.78	0.00	121C/1H, >15PSI	FILM ADHESIVE
FM 73U	0.74	0.00	121C/1H, >15PSI	FILM ADHESIVE, UNSUPPORTED
HT424	0.45	0.00	170C/1H	FILM ADHESIVE FOR COMPOSITE BONDING
RTV 142 SILICONE	0.24	0.00	RT/10D	ONE COMPONENT WHITE SEALANT
RTV 566	0.11	0.01	RT/7D	TWO COMPONENT RTV SILICONE
RTV 567A/B	0.53	0.01	RT/5D	TRANSPARENT RTV SILICONE RUBBER
SCOTCHWELD 2216 B/A 5/7	0.77	0.04	RT/7D	GENERAL PURPOSE EPOXY %WVR = 0.23

6.2.2.2 Paints/Coatings, Foams, Potting/Staking Compounds

6.2.2.2.1 Paints, Coatings, Primers

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ARATHANE 5750 A/B	0.41	0.03	RT/14H + 60C/2H	CONFORMAL COATING
BR-127	0.48	0.03	125C/90M	EPOXY PRIMER, 10% SOLIDS
PARYLENE C MIL-I-46058 Type XY	0.13	0.01	25°C	CONFORMAL COATING

6.2.2.2.2 Foams

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ETHAFOAM 220	0.36	0.08	ARFM	CLOSED CELL POLYETHYLENE FOAM; 2.2 PCF.
ETHAFOAM 400	0.26	0.04	ARFM	CLOSED CELL POLYETHYLENE FOAM; 4.0 PCF.
ETHAFOAM 600	0.24	0.04	ARFM	CLOSED CELL POLYETHYLENE FOAM; 6.0 PCF.

6.2.2.2.3 Potting/Staking Compounds

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ARATHANE 5753 A/B	0.87	0.01	RT/24H	POLYURETHANE POTTING COMPOUND
BR-626	0.72	0.01	121C/1H	ONE-PART MICROBALLOON-FILLED EPOXY POTTING COMPOUND
STYCAST 2651 MM/9	0.38	0.00	RT/7D	LOW VISCOSITY THERMALLY CONDUCTIVE EPOXY; CHECK SPECIFICATION FOR APPROPRIATE CURE.
STYCAST 2651/9	0.37	0.03	RT/8H	THERMALLY CONDUCTIVE EPOXY; CHECK SPECIFICATION FOR APPROPRIATE CURE.
STYCAST 2850 FT/9I	0.25	0.00	RT/16H + 65C/2H	THERMALLY CONDUCTIVE EPOXY
STYCAST 2850 GT/9	0.33	0.01	RT/24H	THERMALLY CONDUCTIVE EPOXY

6.2.2.3 Core

MIL-C-7438 Aluminum Honeycomb

6.2.2.4 Elastomers and Rubbers

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
CHO-SEAL 1215	0.28	0.09	ARFM	RFI GASKET SILICONE FILLED WITH AG/CU
CHO-SEAL 1285	0.62	0.09	ARFM	RFI GASKET SILICONE FILLED WITH AG/AL
KALREZ 1045	0.26	0.02	ARFM	PERFLUOROELASTOMER

6.2.2.5 Fluids, Gas and Liquids

MIL-A-18455
MIL-PRF-27404
MIL-PRF-27407

6.2.2.6 Cable, Sleeving and Tubing

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
SLEEVING MIL-I-22129	0.01	0.00	ARFM	PTFE SLEEVING
VITON SHRINK SLEEVING AMS-DTL-23053/13	0.47	0.05	ARFM	VITON INSULATION, A FLUORO-ELASTOMER

6.2.2.7 Lubricants

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
APIEZON H	0.25	0.04	N/A	HYDROCARBON GREASE
BRAYCO 815Z	0.17	0.07	N/A	FLUOROCARBON OIL
BRAYCOTE 601EF	0.09	0.04	N/A	GREASE; BASE MATERIAL IS BRAYCO 815Z.
BRAYCOTE 602EF	0.09	0.04	N/A	GREASE; BASE MATERIAL IS BRAYCO 815Z. EQUIVALENT TO BRAYCOTE 601EF WITH MOLYBDENUM DISULFIDE ADDED
TIOLUBE 1175, MIL-PRF-81329, AS 1701 CLASS VI	0.76	0.06	N/A	MOLYBDENUM DISULFIDE DRY FILM LUBRICANT

6.2.2.8 Plastics, Laminates

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
DELRIN ASTM D 4181	0.39	0.02	ARFM	ALL GRADES
KEL-F, MIL-P-46036, AMS 3650	0.03	0.01	ARFM	CHLOROFLUOROPOLYMER
LEXAN MIL-P-81390, ASTM D 3935	0.19	0.01	ARFM	POLYCARBONATE
PEEK 450G MIL-P-46183 TYPE I	0.20	0.00	N/A	PEEK (POLYETHERETHERKETON) THERMOPLASTIC; NONREINFORCED
PEEK 450GL30 MIL-P-46183 TYPE II CLASS 2	0.20	0.00	N/A	PEEK (POLYETHERETHERKETON) THERMOPLASTIC; GLASS FIBER REINFORCED
POLYSULFONE P1700 MIL-P-46120	0.09	0.02	N/A	HIGH-TEMPERATURE MATERIAL
REXOLITE 1422 L-P-516, Type E2	0.16	0.02	N/A	CROSSLINKED POLYSTYRENE FOR UHF APPLICATIONS
RT/DUROID 5880 MIL-P-13949/7 TYPE GR	0.03	0.00	N/A	GLASS/TEFLON LAMINATE W/ COPPER CLAD
RT/DUROID 6010	0.03	0.00	N/A	CERAMIC-FILLED PTFE LAMINATE W/COPPER CLAD, DIELECTRIC CONSTANT = 10.5
TEFLON FEP ASTM D 2116	0.02	0.00	ARFM	FLUOROPOLYMER
TEFLON PTFE ASTM D 1457, ASTM D 1710	0.04	0.00	ARFM	ALL GRADES, FILLED OR UNFILLED
TEFZEL ASTM D 3159	0.12	0.02	N/A	FLUOROPOLYMER CEMENTABLE FILM
ETFE TEFZEL ASTM D 3159	0.12	0.02	N/A	FLUOROPOLYMER CEMENTABLE FILM

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
TEFZEL TUBING	0.12	0.02	N/A	TUBING, ETFE (TEFZEL)
TORLON 5030	0.42	0.00	N/A	POLYAMIDE-IMIDE WVR 0.22%
TEFLON PFA TUBING	0.01	0.00	N/A	TUBING, TEFLON PFA
ULTEM 1000 ASTM D 5205	0.40	0.00	N/A	POLYETHERIMIDE, UNFILLED, %WVR = 0.16

6.2.2.9 Films, Tapes, and Adhesive Tapes

6.2.2.9.1 Films and Tapes

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ALUMINIZED KAPTON BLACK/ GERMANIUM	1.59	0.00	ARFM	CARBON-FILLED KAPTON (100XC) COATED WITH GERMANIUM ON ONE SIDE AND ALUMINUM ON THE OTHER SIDE %WVR = 1.48
ITO/KAPTON FILM	0.42	0.05	N/A	ALUMINIZED FILM W/CONDUCTIVE COATING FOR ESD
KAPTON MIL-P-46112	1.04	0.01	N/A	NATURAL POLYIMIDE FILM TYPE VN; TYPE V NO LONGER AVAILABLE. %WVR = 1.00
KAPTON BLACK	0.50	0.02	N/A	CARBON FILLED KAPTON, W OR W/O ITO AND ALUMINIZATION
KAPTON BLACK/GERMANIUM	0.50	0.02	N/A	CARBON-FILLED KAPTON (100CB) COATED WITH GERMANIUM
KAPTON BLACK/GERMANIUM	0.52	0.03	N/A	CARBON FILLED KAPTON, COATED WITH GERMANIUM (LOW DENSITY REINFORCEMENT)
KAPTON BLACK/GERMANIUM/ E1070 FIBERGLASS	0.26	0.02	N/A	POLYIMIDE FILM FILLED WITH CARBON BLACK AND COATED WITH GERMANIUM
KAPTON/AL/FIBERGLASS	0.42	0.08	N/A	GLASS REINFORCED WITH POLYESTER ADHESIVE, ALUMINIZED KAPTON
KAPTON/AL	0.11	0.01	N/A	SINGLE-SIDED ALUMINIZED KAPTON
AL/KAPTON/AL	0.20	0.01	N/A	DOUBLE-SIDED ALUMINIZED KAPTON
MYLAR/AL	0.25	0.00	N/A	SINGLE-SIDED ALUMINIZED MYLAR
AL/MYLAR/AL	0.25	0.00	N/A	DOUBLE-SIDED ALUMINIZED MYLAR
POLYETHERIMIDE (PEI) ULTEM	0.40	0.00	N/A	HIGH-HEAT-RESISTANT THERMOPLASTIC, FILM OR BULK FORM
TEFLON FILM (FEP) ASTM D 2116	0.01	0.00	N/A	PLAIN AND METALLIZED

6.2.2.9.2 Adhesive Tapes

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
DM-101	0.97	0.02	N/A	ALUMINIZED KAPTON/ACRYLIC PRESSURE-SENSITIVE ADHESIVE
DM-105	0.87	0.00	N/A	REINFORCED, ALUMINIZED KAPTON/ACRYLIC PRESSURE-SENSITIVE ADHESIVE
DM-109	0.97	0.02	N/A	ACRYLIC, TWO-SIDED TAPE (POLYIMIDE CARRIER)
KAPTON TAPE, K-102, 146391	0.78	0.01	N/A	KAPTON/ACRYLIC ADHESIVE

6.2.2.9.3 Thermal Control Materials

MIL-I-631
A-A-55126
MIL-P-46112

6.2.2.10 Microwave

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ECCOSORB FGM-40 Emerson & Cuming Microwave Products	0.16	0.06	ARFM	FILLED SILICONE SHEET (ABSORBER)
ECCOSORB FGM -125 Emerson & Cuming Microwave Products	0.31	0.06	ARFM	FILLED SILICONE SHEET (ABSORBER)
ECCOSORB GDS Emerson & Cuming Microwave Products	0.20	0.08	ARFM	IRON-FILLED SILICONE (ABSORBER)
ECCOSORB MCS Emerson & Cuming Microwave Products	0.30	0.05	ARFM	FILLED SILICONE SHEET (ABSORBER)
ECCOSORB MF-124 Emerson & Cuming Microwave Products	0.08	0.00	ARFM	ABSORBER
ECCOSORB MF500F Emerson & Cuming Microwave Products	0.07	0.01	ARFM	ABSORBER
ECCOSTOCK 0005 Emerson & Cuming Microwave Products	0.29	0.01	N/A	LOW-LOSS MICROWAVE MATERIAL; BAR OR ROD

6.2.2.11 Other Nonmetallic Materials

Designation Manufacturer	Outgassing		Cure Condition	Comments
	%TML	%CVCM		
ALUMINA ASTM D 2442	0.00	0.00	ARFM	HEAT SINK SPACER, SUBSTRATE MATERIAL
COVER GLASS OCLI	0.00	0.00	N/A	FUSED SILICA SOLAR CELL COVER
FUSED SILICA MIL-G-174	0.00	0.00	ARFM	GLASS USED AS MIRROR AND SENSOR SUBSTRATES
LACING TAPE, SUPER GUDE-SPACE DPTH	0.58	0.09	ARFM	DACRON LACING
NET, POLYESTER	0.31	0.03	ARFM	POLYESTER NETTING
SAPPHIRE	0.00	0.00	ARFM	HIGH-TEMPERATURE DIELECTRIC FOR USE IN RF DEVICES
THREAD, ASTROQUARTZ	0.00	0.00	ARFM	GLASS THREAD WITH PTFE COATING
THREAD, FLUORGLAS	0.03	0.00	ARFM	GLASS THREAD WITH TEFLON COATING

6.3 Approved Processes

6.3.1 Adhesive Bonding

Specification	Process Description Title
MIL-HDBK-83377 (FOR REFERENCE)	STRUCTURAL ADHESIVE BONDING
MIL-A-83376 (CANCELED; NOT FOR FUTURE DESIGN)	NONSTRUCTURAL ADHESIVE BONDING
MSFC-SPEC-445 (FOR REFERENCE)	REQUIREMENTS FOR ADHESIVE BONDING, PROCESS, AND INSPECTION

6.3.2 Brazing, Welding, and Soldering

Specification	Process Description Title
AWS D17.2	RESISTANCE WELDING
AWS D17.1, MIL-STD-2219	FUSION WELDING
AWS C3.4	TORCH BRAZING
AWS C3.5	INDUCTION BRAZING
AWS C3.6	FURNACE BRAZING
AWS C3.9	RESISTANCE BRAZING
AWS C3.7	ALUMINUM BRAZING

6.3.3 Heat Treating and Surface Hardening

Specification	Process Description Title
AMS-H-81200, MSFC-SPEC-469	HEAT TREATMENT OF TITANIUM AND TITANIUM ALLOYS
AMS-H-6875, AMS 2759	HEAT TREATMENT OF STEEL
AMS-H-7199, AMS 2728	HEAT TREATMENT OF COPPER-BE ALLOYS
AMS 2772	HEAT TREATMENT OF ALUMINUM ALLOYS, RAW MATERIALS
AMS 2771	HEAT TREATMENT OF ALUMINUM ALLOYS, CASTINGS
AMS 2770	HEAT TREATMENT OF ALUMINUM ALLOYS, PARTS
AMS2773	HEAT TREATMENT, CAST NICKEL ALLOY AND COBALT ALLOY PARTS
AMS2774	HEAT TREATMENT, WROUGHT NICKEL ALLOY AND COBALT ALLOY PARTS
ASTM B 661	STANDARD PRACTICE FOR HEAT TREATMENT OF MAGNESIUM ALLOYS
AMS 2768	HEAT TREATMENT OF MAGNESIUM ALLOY CASTINGS
AMS 2762	CARBURIZING LOW ALLOY STEEL PARTS
MSFC-SPEC-469	SPECIFICATION TITANIUM AND TITANIUM ALLOYS, HEAT TREATMENT OF

6.3.4 Metal Fabrication Assembly

Specification	Process Description Title
AMS 2430	SHOT PEENING

6.3.5 Metal Machining–Chemical Milling

Specification	Process Description Title
SAE-AMS-C-81769	CHEMICAL MILLING OF METALS, SPECIFICATION FOR

6.3.6 Platings and Coatings

Designation	Specification	Remarks
ANODIZE, CLEAR (CHROMIC ACID)	MIL-A-8625 Type I Class 1	SEE NOTES 1 and 2.
ANODIZE, CLEAR (SULPHURIC ACID)	MIL-A-8625 Type II Class 1	SEE NOTES 2 and 3.

Designation	Specification	Remarks
ANODIZE, HARD	MIL-A-8625 Type III Class 1	NOT RECOMMENDED FOR USE ON 2XXX SERIES OR CASTING ALLOYS AND WHERE HIGH FATIGUE RESISTANCE IS REQUIRED; SEE NOTES 2 and 4.
CHEMICAL FILM	MIL-DTL-5541 Type I Class 1A, MIL-DTL-5541 Type I Class 3	CLASS 3 IS FOR LOW ELECTRICAL RESISTANCE.

1. Chromic acid anodizing shall not be used on aluminum alloys containing more than 5% nominal copper, more than 7% nominal silicon, or if total allowable contents of nominal alloying elements exceed 7.5%.
2. Anodizing forms an electrically insulating surface. Whenever grounding to an anodized part is required, that area must be free of anodize. A conductive chemical film per MIL-DTL-5541 Class 3 shall be utilized to protect bare areas.
3. Do not use on Aluminum Alloys 2000, 7000, and 8000 series.
4. Do not use MIL-A-8625 Type III coating on aluminum alloys with a nominal copper content in excess of 5% by weight.

Appendix B. Requirements for Category II EEEE Parts

1. Application

This appendix defines the minimum technical requirements for the Program PMP selected for Category II applications. The technical requirements are derived from the unit- and system-level requirements defined by SMC-S-016 FMECA, RAAA, and WCA as defined by SMC-S-013 and the worst case stress derating application requirements as defined by this standard. Tables B-1 through B-14 provide a preliminary set of failure mechanisms and potential mitigations to be considered when selecting the requirement for active and passive devices for Category II applications.

2. Requirements

2.1 All active EEEE parts selected for use shall have a minimum –40°C to +85°C operating temperature range unless exposed to other than –34°C to +10°C of margin (as defined by the manufacturer's operating temperature range) over the minimum and maximum unit qualification temperatures required by the SMC-S-016. All passive EEEE parts selected for use shall have a minimum operating temperature range –55°C to +125°C. For plastic-encapsulated EEEE the parts selected shall have a minimum glass transition (Tg) temperature rating of 10°C above the maximum rated operating temperature value.

2.2 The contractor shall identify all special design application requirements for each part, material, and/or process, and shall verify they are met by the part, material, and/or process selected for the application.

2.3 All parts and materials critical parameters shall be verified to meet the established performance requirements as derived from the WCA per SMC-S-013 over the maximum temperature range established under 2.1 above.

2.4 All EEEE parts operating under switching applications (e.g., current, voltage) shall be verified to have at least 100% margin over the expected current or voltage surge levels during operations.

2.5 All parts and materials selected for the application shall be verified to have 2x design fatigue margin with respect to expected operating environments (include all ground-level testing and launch/mission operating conditions) while meeting all the expected mission functional requirements.

2.6 The contractor shall verify that all potential parts, materials, and processes associated failure modes identified by the ELV FMECA as required by the SMC-S-013 are addressed.

2.6.1 The contractor shall verify that the part and/or material manufacturer has identified and addressed the design of the part and/or material failure modes and the associated causes or mechanisms. The failure mechanisms and mitigation strategies shall be validated initially and for every subsequent major design change implemented. (Note: The contractor is considered to be the manufacturer and shall provide the same information for all internally manufactured parts, materials, and/or internal use processes.)

2.6.1.1 The contractor shall verify that the part and/or material manufacturer-implemented mitigation strategies for the identified failure modes reduce infant mortality and operational failures consistent with the failure rates used in the reliability analysis. The failure mechanisms and mitigation strategies listed in Tables B-1 through B-14 for EEEE parts are a starting point and may not be applicable to all designs and technologies.

2.6.1.2 The contractor shall implement additional mitigations where the manufacturer design and mitigation strategies are not satisfactory at the part level, including electrical testing over temperature, stress testing to validate maximum ratings, DPA, etc.

2.6.2 The contractor shall verify that the manufacturer has identified the process failure modes and their associated failure causes or mechanisms.

2.6.2.1 The contractor shall verify that the part, material, and/or process manufacturer-implemented mitigation strategies for the identified process failure modes reduce infant mortality and operational failures consistent with the failure rates used in the reliability analysis. The failure mechanisms and mitigation strategies listed in Tables B-1 through B-14 for EEEE parts are a starting point and may not be applicable to all designs and technologies.

2.6.2.2 The contractor shall implement additional mitigations where the manufacturer process mitigation strategies are not satisfactory,

2.7 The contractor shall verify the manufacturer has and maintains design and product/process flow diagrams records for the part, material, and/or process. The contractor shall require notifications of all major changes affecting the procured part or material.

2.8 The contractor shall verify the manufacturer-implemented controls adequate to maintain uniform product lot-to-lot and within expected performance distribution consistent with the application requirements.

2.9 To minimize reachback/reachforward in case of failure, the contractor shall verify the manufacturer has a traceability system capable of tracing back to specific manufacturing steps (e.g., wafer lot, wafer fabrication location, assembly lot, etc.) from a given lot or batch number.

2.10 The contractor shall verify the manufacturer has implemented process controls that assure the product variability meets the application requirements.

2.11 The contractor shall verify the manufacturer has identified criteria to quantify high-risk manufacturing processes and implemented corrective action to bring these processes under acceptable risk.

2.12 The contractor shall implement a test program to ensure the elimination of EEEE parts early and infant mortality failures associated with the known failure mechanisms, including those listed in Tables B-1 through B-14 commensurate with the mission duration, redundancy approach, and program risk posture.

2.13 The contractor shall implement a qualification program to ensure the EEEE technology design and construction meets the worst case application requirements with margin. The contractor shall verify that the qualification was performed on representative parts, materials, and processes procured for use on flight units. The contractor shall verify subsequent changes to the parts, materials and processes do not invalidate the original qualification or if they do, they are appropriately qualified.

Table B-1. Active Devices Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Galvanic corrosion	Spec requirement no dissimilar metals; Internal visual; accelerated in-process monitor; use/fly parts right away and in short missions; store in dry atmospheric conditions.	DPA; cross-sections and visual
Ionic corrosion	Cleaning, visual inspection, high temperature reverse bias, electrical verification; use/fly parts right away and in short missions; store in dry atmospheric conditions; low voltage applications	DPA; cross-sections and visual
Dissimilar metals (Cu or Au wire to Al metal)	Special process controls, cleanliness, 300°C bake in-process monitor	DPA; cross-sections and visual
Electromigration	Design rules for current density; derating; application limits for max currents	Accelerated life tests
Surface inversion (mobile ions)	Cleaning, visual inspection, high temperature reverse bias, electrical verification; limit applications to low voltages, wafer fab process monitors	High temperature reverse bias tests, CV plots
Hot carrier injection	Special wafer fabrication processes; design rules for oxide thickness	Modeling; electrical verification over temperature
Stress migration	Metallization design rules; low temperature exposure	High temperature and temperature cycling
Time dependent dielectric breakdown	Special wafer fabrication processes; design rules for oxide thickness; voltage derating	Life test; ramped voltage breakdown test
Dielectric/thin-film cracking	Interlayers design rules	Temperature cycling/shock
Lifted wire bonds	Wire bonder setup and monitor; special encapsulation process controls; Tg selection; electrical testing over temperature	Temperature cycling; thermal shock; electrical testing over temperature; DPA
Fractured/broken bond wires	Wire bonder setup and monitor; special encapsulation process controls; Tg selection; electrical testing over temperature	Temperature cycling; thermal shock; electrical testing over temperature; DPA
Cracked/lifted die	Manufacturing in-process controls; electrical testing over temperature; visual inspection	High and low temperature operations; temperature cycling/shock; DPA
Package cracking	Manufacturing in-process controls; electrical testing over temperature; visual inspection	High and low temperature operations; temperature cycling/shock; HAST; C-SAM; DPA
Seal voids (hermetic sealed devices)	Seal process setup/monitors, seal test, radiography	Seal test; radiography; RGA; visual inspection; PA; dye penetrant

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Encapsulation voids (PEMs)	Encapsulation process and mold controls	C-SAM; HAST; DPA; visual
Loose particles in package (hermetic sealed devices)	Cleanliness controls; PIND cleaning prior to seal; PIND getter	PIND tests
Outgassing	Use of low outgassing materials; vacuum bake	Testing per ASTM E595

Table B-2. Ceramic Capacitors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Dielectric breakdown due to voltage	Increase dielectric thickness, voltage derating of part; improve in-process controls for the elimination of voids, delaminations, and other dielectric defects; improve choice of materials used in the design and construction of the parts.	Voltage conditioning between 2X and 4X rated voltage, life test at 2X rated voltage; perform dielectric breakdown testing and voltage temperature coefficient (VTC) on samples; screen using CSAM, thermal shock, voltage burn-in, electrical tests (DWV, room and hot IR, partial discharge when in corona region); perform DPA with SEM/EDX analysis of dielectric
Electromigration under low voltage	Increase dielectric thickness, voltage derating of part; improve in-process controls for the elimination of voids, delaminations, and other dielectric defects; improve choice of materials used in the design and construction of the parts.	Rated voltage 85/85 using 100K ohm series resistors; in-process or finished lot DPA; CSAM screen
Cracks	Improve in-process controls during ceramic capacitor manufacturing, handling, installation, and installation rework.	Thermal shock; CSAM; voltage burn-in; DPA; rated voltage 85/85 or moisture resistance test; life test; x-ray and vicinal illumination inspection; electrical tests (DWV, room and hot IR, partial discharge when in corona region)
Termination separation	Improve in-process controls for termination processes and improve selection of materials for terminations.	Thermal shock; DPA; pull/shear test; electrical tests (capacitance, DF)
Corona inception (1000V min. rated capacitors)	Improve in-process controls to eliminate dielectric defects; proper voltage derating.	Partial discharge testing, corona inception testing up to 60% of rated voltage; CSAM screening; voltage burn-in; life test; electrical tests (DWV, room and hot IR)
Dielectric aging	De-age capacitors.	Measure capacitance value before use to ensure they are within tolerance.

Table B-3. Tantalum Capacitors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Dielectric breakdown/ high leakage currents	In-process manufacturing controls to minimize dielectric defects; voltage derating; eliminate excessive inrush currents; proper polarity marking on the CCA; limit high ripple currents in the application; ensure no reverse voltage; implement controls to limit moisture and excessive heat during installation and installation rework	Perform surge current screening before Weibull grading; life test; electrical tests; eliminate outlier population.
Contamination, or electrolyte leakage (wet slug only)	Improve installation processes to preclude sealing solder reflow; ensure adequate seals; use only noncompression type seals for wet slug tantalum capacitors	Thermal shock; voltage burn-in; electrical tests; seal tests (fine and gross); radiography to verify tubelet and header solder seals; life test; random vibration test; DPA
Internal solder reflow	Temperature and dwell time control during installation/rework; visual inspection	Radiography; visual inspection; DPA, electrical tests; seal tests
Marginal/damaged internal connections (cathode connections and/or internal riser)	In-process visual inspection of connections; controlled temperature and dwell times during installation/rework; limit moisture before installation	Radiography; ESR measurements; eliminate outlier population; DPA; stability at low and high temperatures
Intermittent during vibration (wet slug tantalums only)	Improve design for high random vibration levels (H designated parts)	X-ray inspection to verify proper seating and snug fit of vibration spacer; DPA; monitored random vibration test on lot samples
Electrolyte contamination	In-process controls during capacitor manufacturing	Voltage burn-in; electrical tests; stability at low and high temperatures; visual inspection; life test, DPA

Table B-4. Mica Capacitors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Intermittent open	Metallurgical bond design of leads to capacitor element	X-ray inspection; thermal shock; vibration; DPA
Dielectric breakdown	Improve in-process controls during capacitor manufacturing, visual inspections under magnification, assembly and handling improvements; ensure proper voltage derating	Thermal shock; voltage burn-in; DWV; room and hot IR; life test; partial discharge when in corona region

Table B-5. Metallized Plastic Capacitors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Intermittent shorts in high impedance applications due to pinholes in dielectric	Ensure there is enough energy (500 uJ) in capacitor application to clear the short or use in low impedance applications.	Low voltage ramp test; thermal shock; high impedance burn-in and life test; electrical tests
Cracks/creases in the element material	Incoming material control and in-process controls during capacitor manufacturing; voltage derating; in-process controls during installation/ rework; seal test; electrical testing	Thermal shock; burn-in; radiography; DWV; room and hot IR; seal test; life test; DPA
Intermittent and/or open	In-process controls of termination attachment to element winding, visual inspection; design for high vibration levels; derating in application; in-process controls during installation/ rework	Thermal shock; AC burn-in and life test; electrical tests; radiography; vibration; DPA

Table B-6. Connectors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Cracks in dielectric (inserts), contamination	In-process controls during dielectric manufacturing; monitoring of dielectric molding dies; contamination control	100% DWV and insulation resistance measurements between pins and between pins and shell; visual inspection; thermal shock testing; real time x-ray; ensure proper installation and handling during mate/demate
Intermittents (especially in RF connectors)	Proper assembly of connector elements	Monitored vibration tests; ensure application parameters are not violating connector parameters of operation; look for inherent weaknesses in contact design and overall connector design
Intermittents, shorts, opens	In-process controls; visual inspection under magnification; internal dimensional analysis and tolerance stack-up	Improper mating-demating; incorrect interfacial dimensions; perform visual inspection and dimensional analysis; improper or insufficient plating of contact surfaces; contamination
High contact resistance	In-process controls and review of materials used; visual inspection for any evidence of contamination of contacts	Inspect contacts for contamination, corrosion; review materials for outgassing, proper plating thicknesses.
Bent pins/contacts	Visual inspection of connector mating surfaces under magnification, before and after each mate-demate	Usually the result of improper observation of mate demate procedures causing torqueing and damage of pins/contacts

Table B-7. Filtered Pin Connectors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Contamination, dendritic growth	In-process cleaning and contamination controls during filter connector assembly; eliminate bare silver terminations on finished arrays	100% voltage burn-in, realtime x-ray; 100% DWV and insulation resistance tests (room temperature and 125°C) pin-to-pin and pin-to-shell of filtered connectors; moisture resistance tests; life test; electrical tests; visual and final inspections; sample DPA on arrays and finished connectors
Cracked elements (capacitors or inductors)	Improve design and choice of materials for holding arrays and inductors in place; implement controlled procedures for handling, mate/demate, visual inspection at next higher assembly; ensure controlled temperatures and dwell times during cabling; perform 100% DWV and IR (pin-to-pin, pin-to-case) of finished cable assemblies; mounting configuration in next assembly.	100% thermal shock; voltage burn-in; realtime x-ray; 100% DWV and insulation resistance tests (room temperature and 125°C) pin-to-pin and pin-to-shell of filtered connectors; shock, vibration and moisture resistance tests; life test; electrical tests; 100% in-process CSAM on the ceramic arrays; visual and final inspections; sample DPA on arrays and finished connectors
Excessive mating and demating forces	Review insert integrity and dimensions; tolerance stack up analysis	Perform mate and demate force testing; external visual inspection; dimensional analysis; DPA.

Table B-8. EMI Feedthrough Filters Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Solder seal reflow (tubelet/header)	In-process controls during sealing operations; controlled temperatures and dwell times during installation/ rework	Realtime x-ray; fine and gross seal tests; DPA
Cracked glass seal	In-process controls during filter manufacturing controlled temperatures and dwell times during installation/ rework	Fine and gross seal tests; visual inspection; DPA
Contamination on glass seals or discoidal capacitor surfaces (high resistance short)	In-process cleaning and contamination controls during filter manufacturing, and during installation	IR measurements; visual inspection; DPA
See ceramic capacitor related failure mechanisms/modes	See Table B-2.	See Table B-2.

Table B-9. Fuses (Hollow Body) Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Increased resistance/ open circuit	In-process controls during fuse manufacturing and lead forming; visual inspection; controlled temperature and dwell times during installation/rework; electrical tests; monitored thermal cycling; shock, vibration	DCR measurements; visual inspection; 100% monitored thermal cycling for continuity; realtime x-ray; electrical tests; shock, vibration tests; terminal strength test; check for loose end-caps; DPA

Table B-10. Relays Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Improper actuation of relay	In-process controls during assembly of relay motor and motor-to-header operations; preseal visual inspection under magnification	Check actuating coils for continuity; perform realtime x-ray; perform external visual inspection; perform vibration-miss test; perform construction analysis to determine if there is potential for worst case tolerance stack up and interference; perform internal visual (precap) or during DPA to see if there is any evidence of debris or contamination.
Intermittent sticking of contacts	In-process controls and control of materials and platings for contacts; contamination control inclusive of FOD	Check for thin film or cold welding evidence when performing DPA; perform multiple actuations. Perform realtime x-ray; review platings and perform analysis for prohibited materials, in particular for pure tin presence.
Shorting of contacts	In-process controls and control of materials and platings for contacts	Perform DPA and look closely; check for any evidence of solder, weld splatter, splatter, and conductive FOD; perform vibration miss test; check for simultaneous open-close commands being issued to the relay.
Contacts stuck in neutral position	Perform in-process visual inspections and tolerance checks for misalignments and under- or over-travel of moving elements.	Actuate relay to see if relay becomes unstuck.

Table B-11. Resistors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Resistance drift	In-process contamination and FOD controls during resistor manufacturing; control heat treat of element; improve element design and materials choices, including passivation/coating; visual inspection; control installation/rework temperatures and dwell times	Thermal shock; short time overload, power burn-in; internal and external visual inspection; life test; moisture resistance test; high temperature exposure test; resistance temperature coefficient; DPA
Intermittent/opens	In-process controls during resistor manufacturing; improve design and materials choice for terminations, or coatings that protect the element from contamination; visual inspection; controlled handling, cleaning, temperature and dwell times during installation/rework	Internal and external visual inspection; thermal shock; short time overload; power burn-in; life test; shear/flex tests of terminations; pull testing of leaded products; shock; vibration; DPA

Table B-12. Thermistors/Temperature Sensors Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Zone slippage/ fracture (platinum wire only)	In-process controls during the assembly and manufacture of the thermistors	Temperature cycling/thermal shock CTE interactions of encapsulating material (glass, epoxy, etc.) and fine platinum wires
Intermittent/open terminations	In-process visual inspection of termination areas before and after lead attachment	Temperature cycling/thermal shock

Table B-13. Switches (Thermal) Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Changing set-points of the switch	Critical design and construction analysis; control of materials and processes; in-process inspections and dimensional verifications	Temperature cycling/thermal shock CTE interactions of encapsulating material (glass, epoxy, etc.) and fine platinum wires

Table B-14. Switches (Electromechanical) Failure Mechanisms and Mitigations

Failure Mechanism	Potential Mitigation	Possible Verification Methods
Failure of switches to actuate, or getting stuck in one position (open or closed)	Tolerance stack-up analysis; in-process material and assembly process control; in-process contamination (FOD also) controls; visual inspection; like electro-mechanical relays, these devices should be assembled in clean room environments	Actuation of switch during temperature cycling (several hundred cycles at each temperature if not more), preceded by sinusoidal and random vibration tests; 100% realtime x-ray inspection

Appendix C. Printed Wiring Board Manufacturing and Screening Requirements

1. Scope

This section sets forth detailed requirements for the following printed wiring board types:

Type 1: Printed wiring boards with only one conductive layer (single-sided conductor pattern) with cover lay and no plating in component holes

Type 2: Rigid printed wiring boards with conductor patterns on both sides of printed board (double sided). In addition, the board may require plated-through holes in order to connect conductor patterns on both sides

Type 3: Multilayer printed wiring boards (three or more conductive layers) with plated holes. Type 3 designs include metal cores.

Type 4: Multilayer printed wiring boards (three or more conductive layers) with plated holes and blind or buried via holes.

2. Application

2.1 General Requirements

Printed wiring boards shall be designed in accordance with IPC 2221 Class 3, IPC 2222 Class 3, and IPC 2223 Class 3 and fabricated in accordance with IPC 6012 Class 3/A, IPC 6013 Class 3, MIL-PRF-31032, MIL-PRF-50884 or MIL-PRF-55110 and this document. The contractor shall demonstrate that all the processes used to design, qualify, manufacture, and test products are documented and meet all program requirements. In case of conflict, the provisions of this document shall apply.

2.2 Qualifications

The manufacturer shall be qualified to MIL-PRF-55110 or MIL-PRF-31032 and MIL-PRF-50884 as applicable. If the supplier is only certified to IPC 6012 Class 3/A or IPC 6013 Class 3, the contractor shall verify by audit that the build documentation, in- process controls, qualification testing, and construction review meet the program requirements.

3. Design and Construction

Printed wiring boards shall be designed such that primary and redundant circuits are isolated from each other. A single failure in either circuit shall not affect the other circuit.

3.1 Rigid Printed Wiring Boards

Rigid printed circuit boards with plated through holes shall be in accordance with the requirements of IPC 2221 Class 3, IPC 2222 Class 3, and manufactured in accordance with MIL-PRF-55110, MIL-PRF-31032 or IPC 6012 Class 3/A and the following:

1. **Nonfunctional Lands (Internal Layers)**
   Nonfunctional lands shall be included on internal layers of multilayer boards whenever clearance requirements permit.

2. **Etch Back**
   Etch back is required and shall be performed in accordance with the detailed requirements of MIL-PRF-55110, MIL-PRF-31032, or IPC-6012.

3. **Drill Bit Limit**
   The board manufacturer shall have a process to define, verify, and maintain a matrix, which identifies the optimum number of drill bits allowed for specific types of materials, number of layers, and hole diameters. The process shall also detail number of allowed re-sharps and drill bit hit limits for resharpened bits.

4. **Drill Changes**
   All drill bit changes shall be documented and recorded. The record may be in the form of a drill tape or any digital storage medium.

5. **Stacking for Drilling Plated Through Holes**
   Stacked drilling shall not be permitted for multilayer or double-sided boards. Only drilling of single high panels shall be allowed.

6. **Tin-Lead Plating**
   Tin-lead plating thickness shall be 0.0003 inches minimum before fusing. There shall be no solder plate on any surface which is to be laminated to an insulator, metal frame, heat sink, or stiffener.

7. **Fusing**
   After solder plating and other processes, unless otherwise specified on the source control drawing (SCD), the printed wiring board shall be fused. The manufacturer shall be limited to one fusing operation, whether or not the fusing process heats one or both sides of the board. The fuse time and temperature shall be recorded. After fusing, the solder coating shall be homogeneous, shall completely cover the conductors without pitting or pinholing, and shall show no nonwet areas. Side walls of the conductors do not have to be solder coated. Touch-up is permitted, but must be documented.

8. **Ductility and Tensile Strength**
   A method for monitoring copper plating baths shall be used to ensure that measured elongation of as-plated copper from the bath meets or exceeds 18% with a minimum tensile strength of 40 kpsi.

9. **Process Control Coupons**
   Each panel shall include process-control coupons to ensure that the manufacturing processes are under control. At a minimum, the following fabrication steps shall have process coupons: drilling, etch-back, and Cu plating. Process-control coupon holes shall be drilled using drill bits that are at or more than allowable hit count.

10. **Quality Conformance Test Coupons**
    The number and locations of Quality Conformance test coupons shall be in accordance with the detail specification of MIL-PRF-55110, MIL-PRF-31032 and or IPC 2221 Class 3 and shall be retained per program requirements.

11. **Coupon Marking**
    Each coupon or test strip shall be suitably marked to retain traceability.

12. **Storage and Retrievability**
    All deliverable coupons shall be stored for the life of the contract or until the entire inspection lot is flown, whichever is sooner.

3.2 Multilayer Printed Circuit Boards

When multilayer printed circuit boards are used, the copper surfaces on all inner layers to be laminated shall be treated or primed prior to lamination to increase the laminate bonding. A copper oxidation technique is an acceptable treatment prior to lamination. Multilayer printed circuit boards shall be configured to equalize, to the greatest extent possible, the distribution of conductive areas in a layer and the distribution of conductive areas among layers. Large conductive areas such as ground planes should be positioned close to the board midpoint thickness. When more than one ground plane is required, they should be in layers that are equidistant from the midpoint thickness.

3.3 Flexible and Rigid-Flex Printed Wiring

Flexible and rigid-flex printed wiring shall be in accordance with the requirements of MIL-PRF-31032, IPC 2223 Class 3, and MIL-PRF-50884, IPC 6013 Class 3.

3.4 Discrete Wiring Boards

Discrete wiring boards with plated through holes shall be in accordance with the requirements of ANSI/IPC-DW-425. Discrete wiring boards shall not be used in flight hardware without PMPCA approval.

4. Quality Assurance

4.1 Screening (100%)

Manufacturer screening and in-process inspection shall be in accordance with the requirements of MIL-PRF-55110, MIL-PRF-31032, MIL-PRF-50884, IPC 6012 Class 3A, and IPC 6013 Class 3. Documentation shall be maintained to demonstrate the procured boards and the conformance coupons meet all their requirements.

4.2 Lot Conformance Testing

Manufacturer lot conformance tests shall be in accordance with the requirements of MIL-PRF-55110, MIL-PRF-31032, MIL-PRF-50884, IPC 6012 Class 3A, and IPC 6013 Class 3.

Appendix D. Custom Relay Requirements

1. Scope

This section sets forth detailed requirements for electromechanical relays with current rating of 25 amperes or less. All parts selected for the system application shall meet the requirements specified herein. Alternate approaches to meeting particular requirements shall be proven equivalent to or more stringent than specified herein.

2. Application

Selection and application of relays shall be in accordance with MIL-STD-1346 and the requirements contained herein.

2.1 Capacitive Load

Series resistance shall be used with all capacitive load to ensure that currents do not exceed derated levels for resistive loads.

2.2 Suppression

Transient suppression circuitry shall be used on all suppression coils. The circuitry shall be rated to suppress 2X the nominal coil voltage in both polarities. All components included in the circuitry shall meet the requirement of this document regardless if used inside or outside of the relay.

2.3 Coil Voltage

The rated coil voltage over the operating temperature range of the relay shall not be derated during use or application. For pulsed applications when the duty cycle is 10% or less, the coil energizing voltage shall be no greater than 150% of the rated coil voltage, and the maximum allowable “on” time shall be 50 milliseconds.

2.4 Loads

If relay usage is at low or intermediate loads relative to the rated load for the relay, the relay shall also be qualified at the reduced (usage) load.

2.5 Derating

2.5.1 Contact Current Derating

Contact current derating shall be in accordance with Table D-1, and the operating life of the relay. Inrush currents in excess of the rated resistive load may be permitted with a corresponding reduction in life when the following criteria are met:

a. The relay has been qualified to withstand an inrush of X times the rated resistive load for Y number of cycles.

b. Lot-by-lot conformance tests are performed to verify continued compliance.

c. The actual application shall not require more than an inrush of X times the rated resistive load for 50% the specified Y number of cycles.

Table D-1. Contact Current Derating

Contact Load Type	Derating Factor from Rated Resistive Load
Resistive	0.75
Inductive	0.40 of rated resistive load or 0.75 of rated inductive load
Motor	0.20 of rated resistive load or 0.75 of rated motor load
Filament	0.10 of rated resistive load or 0.75 of rated lamp load
Capacitive	(See 2.1)

3. Design and Construction

3.1 Requirements

Design and construction shall be in accordance with the requirements of the applicable specifications, MIL-PRF-6106, MIL-PRF-28776, MIL-PRF-39016, MIL-PRF-83536, and MIL-PRF-83726, and the requirements of this document.

3.1.1 Electronic Parts

Electronic parts that are utilized in manufacturing the relays, such as diodes, transistors, capacitors, and hybrids, shall also meet the applicable requirements stated in their sections of this document.

3.1.2 Critical Processes

The manufacturer shall document the manufacturing flow, including the processes and procedures that have critical effect on the fabrication, function, reliability, or service life of the article. As a minimum, these shall include raw material certification and property sample tests, coil assembly, carrier assembly, contact assembly, armature assembly, coil core and pole piece assembly, motor assembly, relay subassembly prior to closure, and final assembly and closure. Inspections and tests associated with each process and assembly operation shall be included in the processes. As a minimum, the following items shall be considered critical materials: coil assembly, carrier assembly, contact assembly (contacts), armature assembly, coil core, pole piece assembly, motor assembly, wires, and header.

3.1.3 Magnet Wire

Uninsulated coil wire and or wires less than 44 AWG shall not be used. However, when relay designs require coil wires finer than 44 AWG, the coils shall be continuously monitored for continuity during thermal shock test.

3.1.4 Final Assembly

Relays shall be assembled in a clean area. Final cleaning, inspection, and storage shall be done in a controlled clean room environment with laminar flow hood or similar measures to eliminate particulate contamination. After precap visual inspections have been completed, the relays shall be sealed (canned) while in this same controlled clean room environment. If the covers are removed for any reason after preseal visual inspections have been completed but prior to sealing, preseal visual inspections shall be repeated.

4. Quality Assurance

Quality assurance provisions shall be in accordance with Section 4, General Requirements, of this document and the following items.

4.1 In-Process Controls

In-process controls shall be in accordance with the requirements of the applicable military specification, and the following:

4.1.1 Vacuum Bake

Relay coil assemblies shall be vacuum baked to prevent coil outgassing from causing a film buildup on the contacts and increase contact resistance.

4.1.2 General Method of Inspection

4.1.2.1 Visual And Mechanical Examinations

A visual examination shall be performed in a controlled clean room environment with laminar flow hood or similar measures to eliminate particulate contamination, on 100% of the relays prior to final cleaning and assembly in the can.

The examination shall be performed using a 10-power microscope except when an abnormality is observed, then higher magnification (30X-50X) shall be used to verify product integrity. All parts not under immediate inspection shall be stored in covered trays and returned to covered trays immediately after inspection.

4.1.2.2 Initial Inspection

Areas to be visually examined shall include:

a. Contact assembly, contact surfaces, stationary and movable contacts, springs
b. Coil, pole piece, armature, header

4.1.2.3 Final Examination for Contamination

Upon completion of final cleaning, the entire relay assembly shall be inspected. Any particulate contamination visible at 20X magnification shall require resubmission of the lot for another cleaning and final inspection for contamination. During this inspection, the relay shall be rotated into various orientations to utilize all available lighting. Also, this step shall be performed in a controlled clean room environment with a laminar flow hood, or similar setup to eliminate any potential reintroduction of particulate contamination.

4.1.3 Inspection Requirements

4.1.3.1 Moving Contact Assembly and Springs

Inspection of the moving contact assembly for proper installation and position shall be done at 20X. The springs shall clear all adjacent parts for both positions of the armature. Support brackets for the moving contact assembly shall be inspected for cracks and loose fractures at 20X, except relays larger than 1 ampere shall be done at 10X.

4.1.3.2 Contact Surfaces (Fixed and Movable)

Surfaces shall be inspected and rejected for the following conditions:

a. Scratches or burrs in contact mating area and cracked or peeling plating (20X)

b. Improper alignment (i.e., not meeting the manufacturer spec) for either position of the armature (20X)

c. Fibers and other contaminants (20X)

d. Tool marks on the underside of contact supports for (20X); see para 4.1.3.6 in this appendix

e. Weld splatter on contact terminals (20X); see para 4.1.3.6 in this appendix

4.1.3.3 Coil Inspection

Inspect relay coils for the following:

a. Coil lead welds: Inspect for evidence of weld on each coil lead wire, followed by probing of the weld area to verify that each coil lead wire is firmly attached to the terminal (20X). The weld area probing procedure shall be defined to prevent/minimize inducing mechanical damage to the weld joint.

b. Coil lead wires that have been repaired or spliced shall be rejected.

c. Weld splatter at coil terminals shall be rejected (20X). See para 4.1.3.6 in this appendix.

d. Coil lead dress: Coil lead dressing shall ensure clearance to all moving and conductive surfaces Coil leads shall not be kinked and shall not be stretched tight from coil to coil lead post (10X)).

e. Nicks in the coil wire shall be rejected (20X).

f. Loose or frayed insulation that may interfere with normal relay operation shall be rejected (10X).

4.1.3.4 Armature and Pole Piece Gaps

Inspect armature and pole piece gaps for weld splatter and contamination. The presence of either or both shall result in the rejection of the item (20X).

4.1.3.5 Header

The following conditions shall be rejected during header inspection (20X):

a. Tool marks that affect reliability; see para 4.1.3.6 in this appendix
b. Glass seal defects; see para 4.1.3.6 in this appendix
c. Weld splatter; see para 4.1.3.6 in this appendix
d. Cracked or peeling plating
e. Misalignment of header and frame

4.1.3.6 Inspection Criteria

4.1.3.6.1 Weld Splatter

Weld splatter or weld expulsion balls observed under 20X magnification shall be acceptable if they do not come lose when a probing force of 125 ± 5 grams is applied.

4.1.3.6.2 Scratches and Burrs

Scratches or tool marks wholly below the surface of the metal are acceptable. Burrs protruding above the surface are not acceptable.

4.1.3.6.3 Cracks

Cracks in the header pin glass seals shall not be acceptable if the crack length from the pin or outer edge is more than one-third the radius of the seal. This criterion is not applicable to glass seals less than 0.10 inch diameter. In case of dispute, all relays shall meet the insulation resistance, dielectric withstanding voltage, and seal test requirements.

4.1.3.6.4 Teflon

Teflon strands that are an integral part and extension of the Teflon coil wrap or coil lead insulation are acceptable, but Teflon strands that are loose or of sufficient length or in a location where they can interfere with the normal actuation and operation of the relay shall be rejected.

4.1.4 Cleaning

Cleaning shall be performed in a controlled clean room environment with laminar flow hood or similar measures to eliminate particulate contamination. Relays with permanent magnets shall be demagnetized if they can be remagnetized and stabilized after sealing.

4.1.4.1 Ultrasonic Cleaning

Relay trays and covers, unsealed relays, relay lids, and other parts and subassemblies that constitute the final assembly shall be ultrasonically cleaned. Ultrasonic cleaning shall not be performed on sealed relays.

4.1.4.2 Vacuum Cleaning

If vacuum cleaning is performed, then it shall be performed in a laminar flow hood or equivalent that can preclude particulate contamination. Immediately store cleaned parts in clean covered trays.

4.1.4.3 Cleaning and Small Particle Preseal Inspection (Millipore Cleaning)

Test relays, cans, and any other parts or subassemblies that constitute the final assembly shall use the following procedure or equivalent. First obtain reagent-grade solvent compatible with both the relay components and meeting other necessary requirements from prefiltered supply. Assemble precleaned 1000-milliliter flask, vacuum pump, filter holder, precleaned 0.80-micrometer filter, and precleaned funnel. Fill funnel with prefiltered reagent grade solvent and turn vacuum pump on. Repeat until flask is filled. Fill a pressurized container with cleaned reagent-grade solvent. Clean the filter by blowing both surfaces with ionized air. Using the pressurized container, wash both sides of the filter with clean filtered reagent-grade solvent. Observe the filter under 30X magnification; if any particles are observed, repeat the cleaning process until no particles are observed. Place the filter holder and cleaned filter on a clean empty 1000-milliliter flask under a funnel. Air blow all parts to be Millipore cleaned using ionized air. Place parts in a funnel. Using a 1000-milliliter flask of filtered reagent grade solvent, pour the reagent-grade solvent into the funnel, covering the parts to be cleaned. Cover the funnel. Turn on the vacuum pump. When all the reagent-grade solvent has passed through the filter, turn off the vacuum pump. Remove the filter and examine under 30X magnification. If one or more particles 25.4 microns (0.001 inch) or larger are present or if three or more visible particles under 25.4 microns (0.001 inch) are present on the filter, repeat the process until no additional particles are observed. Place cleaned parts in cleaned covered trays in preparation for canning the relays.

4.2 Screening (100%)

Screening (100%) of MIL-PRF-39016 type relays shall be in accordance with the "M" level of the Group A inspections in MIL-PRF-39016, with the additions and exceptions in Table D-2. Screening (100%) of MIL-PRF-6106 type relays shall be in accordance with the ER requirements of the Group A inspections in MIL-PRF-6106 with the additions and exceptions in Table D-2. Screening (100%) of other type relays shall be in accordance with Table D-2.

4.2.1 Vibration Miss Test

For those relays in which the noise signature is characterized by mechanical chatter, the particle impact noise detection (PIND) test might not detect particles. In this case, a vibration miss test shall be used in place of the PIND test. The vibration miss test shall be performed in accordance with the following requirements:

a. Relays shall be vibrated with a 10 g peak sine wave at a fixed frequency of 10 Hz for 3 ± 0.1 minutes.

b. Axis of vibration shall be parallel to contact motion.

c. Relays shall be operated at 9.9 Hz.

d. All contacts shall be monitored for any misses.

e. Relays with misses shall be rejected and removed from the production lot.

4.2.2 Electrical Characteristics

The following electrical characteristics shall be determined in accordance with the requirements in MIL-PRF-39016 or MIL-PRF-83536, as applicable:

a. Contact resistance

b. Operate voltage/set voltage

c. Release voltage, reset

d. Hold voltage for nonlatching relays only

e. Operate/set and release/reset times

f. Contact bounce (MIL-PRF-6106) or contact stabilization time (MIL-PRF-39016 and MIL-PRF-83536)

g. Coil resistance

h. Transient suppression

i. Reverse polarity protection

j. Latch from neutral for magnetic latching only

4.3 Lot Conformance Tests

Lot conformance tests shall be in accordance with the Group B tests in MIL-PRF39016 or MIL-PRF-83536, as applicable, with the following additions:

a. Random vibration and shock shall conform to the requirements of the specific application.
b. Resistance to solder heat shall be per the applicable specification.
c. Internal moisture shall be determined per the applicable specification.

4.4 Qualification Tests

Qualification tests shall be in accordance with MIL-PRF-39016 and MIL-PRF-83536, as applicable.

4.5 Incoming Inspection DPA

Incoming inspection DPA shall be in accordance with MIL-STD-1580, except para 17.1.1.6f(4) shall be 15 lbs minimum for relays in TO-5 cans. All internal and external metal surfaces shall be verified for the absence of prohibited materials (e.g., pure tin, zinc, or cadmium).

5. Reliability Suspect Relays

a. Parts with adjunct seals

b. Soldered-sealed cases

c. Units not subjected to PIND or a vibration miss test

d. External dielectric coatings

e. Plug-in devices

f. Internal suppression diode not conforming to the screening requirements of JANS MIL-PRF-19500 and this specification

g. Coil wires finer than #44 AWG not continuously monitored during thermal shock

6. Prohibited Relays

a. Relays with prohibited materials in their construction or finishes; see Section 4, General Requirements, para 4.3.3 of this document.

Table D-2. 100% Screening Requirements

Tests	Modifications to the requirements, methods, and criteria of MIL-PRF39016, or MIL-PRF-83536, as applicable
Vibration (sine)	Relays shall be vibrated in the axis parallel to contact motion.
Vibration (random)	a. MIL-STD-202, Method 214, Test Condition IG (or the requirements of the application) b. 3 orthogonal planes, 3 minutes c. Mounting fixture shall not add or remove energy from relay under test. d. Monitored for contact chatter, 10 microseconds maximum (or as specified by the application) per MIL-STD-202, Method 310, Circuit B, or equivalent e. No contact transfer (monitoring equipment shall be capable of detecting closures greater than 1 microsecond). f. Energize nonlatch relays during half test time and de-energize during other half.
Thermal shock	a. Per MIL-PRF-6106, MIL-PRF39016, or MIL-PRF-83536, operational reliability requirements b. Five thermal shocks c. Record pickup and dropout voltage. d. For relays with coil gauge wire of AWG 44 or smaller, continually monitor coil continuity with 350 microamperes (maximum current) during last temperature cycle.
Intermittency and particle impact noise detection (PIND)	a. See requirement in para 4.2.1 of this document for the Vibration Miss Test. b. MIL-STD-202, Method 217 detection c. The lot shall be tested a maximum of 5 times. If less than 1% of the lot fails during any of the 5 runs, the lot may be accepted. All defective devices shall be removed after each run. Lots that do not meet the 1% PDA on the fifth run or exceed 25% defectives cumulative shall be rejected.
Electrical characteristics	See requirements in para 4.2.2 of this document.
Insulation resistance	
Dielectric withstanding voltage	a. Sea level only
Radiographic inspection	a. Per MSFC-STD-355, 2 conventional x-ray views 90 degrees apart, or 360-degree view with realtime x-ray (preferred).
Seal	a. Per MIL-PRF-6106 or MIL-PRF-39016, or MIL-PRF-83536 (as applicable)
Visual and mechanical examination (external)	a. Per MIL-PRF-6106 or MIL-PRF-39016, or MIL-PRF-83536 (as applicable) and this section

Appendix E. Wire Constructions

1. Acceptable Constructions

The following wire constructions shall be included in the ELV quality PMP baseline for unlimited use:

Specification	Title/Construction
SAE-AS22759/16	Wire, Electric, Fluoropolymer-Insulated, Extruded ETFE, Medium Weight, Tin-Coated Copper Conductor, 600 Volt, 150°C
SAE-AS22759/17	Wire, Electric, Fluoropolymer-Insulated, Extruded ETFE, Medium Weight, Silver-Coated High-Strength Copper Alloy Conductor, 600 Volt, 150°C
SAE-AS22759/18	Wire, Electric, Fluoropolymer-Insulated, Extruded ETFE, Light Weight, Tin-Coated Copper Conductor, 600 Volt, 150°C
SAE-AS22759/19	Wire, Electric, Fluoropolymer-Insulated, Extruded ETFE, Light Weight, Silver-Coated High-Strength Copper Alloy Conductor, 600 Volt, 150°C
SAE-AS22759/32	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Light Weight, Tin-Coated Copper, 600 Volt, 150°C
SAE-AS22759/33	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Light Weight, Silver-Coated High-Strength Copper Alloy, 600 Volt, 200°C
SAE-AS22759/34	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Tin-Coated Copper, 600 Volt, 150°C
SAE-AS22759/35	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Silver-Coated High-Strength Copper Alloy, 600 Volt, 200°C
SAE-AS22759/41	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Nickel-Coated Copper, 600 Volt, 200°C
SAE-AS22759/42	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Nickel-Coated High-Strength Copper Alloy, 600 Volt, 200°C
SAE-AS22759/43	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Normal Weight, Silver-Coated Copper, 600 Volt, 200°C

Specification	Title/Construction
SAE-AS22759/44	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Light Weight, Nickel-Coated Copper, 600 Volt, 200°C
SAE-AS22759/45	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Light Weight, Nickel-Coated Copper, 600 Volt, 200°C
SAE-AS22759/46	Wire, Electric, Fluoropolymer-Insulated, Crosslinked Modified ETFE, Light Weight, Nickel-Coated High-Strength Copper Alloy, 600 Volt, 200°C
MIL-DTL-17	Cable, Radio Frequency, Flexible and Semi-Rigid, Coax
NEMA-WC27500	Cable, Power, Electrical and Cable Special Purpose, Electrical Shielded and Unshielded, Types SC, SR, SS, ST, SP (Multiconductor)
NASM20995	Wire, Safety or Lock, MS20995 C15, C20, C32, C41, C47, C91, NC20, NC32, NC40, NC51 AND NC91

2. Limited Use Constructions

The following wire constructions are included in the ELV quality PMP baseline and shall only be used for wiring internal to magnetic and inductive parts.

Specification	Title/Construction
J-W-1177	Wire, Magnet, Electrical, General Specification for (Superseded by NEMA-MW1000)
ANSI- NEMA-MW1000	Wire, Magnet, Electrical, General Specification for

3. Reliability Suspect

The following wire constructions shall only be used with approval from PMPCA.

a. Teflon (PTFE) insulated wire in general, though there are specific configurations and applications where PTFE insulated wires are prohibited (see below)

b. FN- or HN-grade polyimide (Kapton) insulated wire

c. Polyalkene insulated wire

d. Polyvinylidene fluoride (PVF2) (Kynar) insulated wire

e. NEMA-WC27500 unshielded-unjacketed cables with four or fewer conductors without 100% wire to wire 1500VAC Dielectric Withstanding Voltage (DWV) for wire rated up to 600V and 2500VAC for wire rated to 1000V to screen out the wire insulation flaws introduced during the cabling manufacturing

4. Prohibited Constructions

The following wire constructions are prohibited from all usage.

a. MIL-DTL-16878 wire types

b. All polyvinyl chloride (PVC) insulated wire and cable

c. SAE-AS22759 wire with only one PTFE layer

d. MIL-W-76 wire

e. Aluminum wire or cable

f. Pure tin-plated wire and braid except as allowed by Section 4, General Requirements, para 4.3.3.1 of this document

g. Teflon (PTFE) insulated wires in application that have a high probability of producing cold flow of the insulation.

h. MIL-DTL-81381 wire

i. MIL-W-81044 or SAE-AS81044 wire

Appendix F. Prohibited and Reliability Suspect Parts and Materials

1. Materials

1.1 Prohibited Materials

1. Corrosive (acetic acid evolving) silicone sealants, adhesives, and coatings are prohibited from use on electronic or electrical equipment.
2. Polyvinyl chloride
3. Materials capable of emitting excessive vacuum condensables, noxious or toxic gases when exposed to low pressure or high temperature shall not be used. Pure zinc, pure cadmium, selenium, or mercury shall not be used. The actual acceptable percentages of zinc and cadmium in alloys or brazes and the extent of overplating, if required, shall be technically substantiated with data for the intended applications and shall require PMPCA approval prior to use. Use of cadmium plating on mechanical fasteners or other parts is not approved on space hardware. Pure tin (Sn) or tin alloy containing less than 3% lead (Pb) shall only be used with PMPCA-approved mitigations. This prohibition also applies to shielding mesh tapes, terminal lugs, brackets, and housings for flight hardware, and/or critical ground equipment designed for launch support. The only exceptions are completely insulated wire products where tin is only used during the drawing process.

See Appendix A for additional materials restrictions for each material type.

2. Prohibited and Reliability Suspect Parts

The following parts have been identified as either prohibited or reliability suspect.

2.1 Capacitors

2.1.1 Prohibited Capacitors

1. Silver-cased wet tantalum slug capacitors (e.g., CLR 65 (MIL-PRF-39006/9))
2. Mica capacitors that do not have metallurgical bond between the capacitor element and leads
3. Glass capacitor styles CYR41, 42, 43, 51, 52, and 53
4. Aluminum electrolytic capacitors
5. Single-seal CLR 79 construction

2.1.2 Reliability Suspect Capacitors

1. Variable capacitors

2.2 Connectors

2.2.1 Prohibited Connectors

1. Connectors using prohibited materials in their construction and plating
2. Noncaptivated RF connector contacts

3. Silver contact overplate or underplate
4. Wire wrap contacts
5. RF cable assemblies using the cable solid center conductor as the mating-interface pin contact in the connector
6. Plastic composite connectors exposed to atomic oxygen environment
7. Insulation displacement connection (IDC) wire terminations
8. Lock washers (split, internal tooth, external tooth, etc.); lock washers are normally supplied with jackpost hardware kits and should be discarded
9. Lubricants used on electrical contacts
10. Open-barrel crimp-contact terminations except for MIL-DTL-83513 microminiature and MIL-DTL-32139 nanominiature contacts, which are crimped and installed into connectors by QPL manufacturers. (Note: Open-barrel contacts that are welded/brazed (closed barrel) are not prohibited.) This does not apply to seamless crimp barrels.
11. Card edge connectors which use PWB pads (lands) as contacts
12. E-clips, C-clips, or snap rings for jackscrew hardware, on spaceflight connectors
13. Crimping solder-dipped or tinned-stranded or solid conductor wiring
14. RTV (room temperature vulcanizing) silicone compounds that are one part acetic acid cure
15. Polyvinyl chloride (PVC)
16. Polyamide (nylon) connector insert material and cable ties
17. Crimping to solid conductors except for MIL-DTL-83513 microminiature and MIL-DTL-32139 nanominiature contacts, which are crimped and installed into connectors by QPL manufacturers.
18. Fuzz buttons

2.2.2 Reliability Suspect Connectors

1. Ferromagnetic materials (e.g., nickel) used on RF connectors where intermodulation of signals would be a problem
2. Filtered pins
3. Dissimilar metal mates
4. External flat cable connectors
5. Multipin connectors without cavity sealing plugs in unused contact cavities of environmental connectors (e.g., those that have silicone or fluorosilicone grommets, reference NASA-STD-8739.4)

6. Soldered terminations of coaxial semirigid cables using other than high-temperature solder for the internal construction

7. Compact PCI connector except GSFC S-311-P-822

8. Gold-over-copper plating schemes operated at temperatures in excess of 150ºC in nonvacuum environments; this will cause the copper to migrate through the gold finish, resulting in corrosion.

9. Power connectors that carry both primary and redundant lines within the same connector

10. Compliant pin (press fit) contacts into printed wiring board (PWB) holes

11. Blind mating (modules, PWB daughterboards to motherboards, etc.) with standard MIL-DTL-83513 microminiature connectors and standard MIL-DTL-32139 nanominiature connectors that are not scoop-proof design, which can damage the exposed socket contact mating barrels, damaging the mating pin contacts. Blind mating connectors shall be accomplished by use of long jackscrews (half turns alternating mate/demate) or by use of long guide pins to bring connector shells together before contacts mate. Blind mating could also be accomplished with modified longer connector shells (e.g., scoop-proof), allowing the shells to engage/align before the contacts mate.

2.3 Crystals

2.3.1 Prohibited Crystals

1. Plug-in types

2.4 Diodes

2.4.1 Reliability Suspect Diodes

1. Diodes in hot-welded cans (uncontrolled weld splatter)

2. Nonglassivated or nonpassivated semiconductor devices without PMPCA approval

3. Devices with gold/aluminum bonds at the die

2.5 Point Contact (Whisker) Diodes without PMPCA Approval Filters

2.5.1 Prohibited Filters

1. EMI/RF filters with tubular ceramic elements

2.6 Fuses

2.6.1 Reliability Suspect Fuses

1. Fuses comprised of low-melting-point alloys

2. Wires used as fuses

3. Any chip or leaded surface mount fuse with conformal coat coverage instead of a molded body or glass arc suppressant

4. Hollow body, wire element fuses

2.6.2 Prohibited Fuses

1. All fuses requiring fuse holders

2. Nonhermetic fuses

2.7 Magnetic Devices

2.7.1 Reliability Suspect Magnetic Devices

1. Devices utilizing smaller gage wire than specified in MIL-STD-981 for Class S

2. Variable magnetic devices

2.8 Microcircuits/Hybrids

2.8.1 Reliability Suspect Microcircuits/Hybrids

1. Devices with gold/aluminum bonds at the die, excluding hybrids

2.9 Relays

2.9.1 Reliability Suspect Relays

1. Plug-in types

2. Solder-sealed relays

3. Parts with adjunct seals

4. Units not subjected to PIND or a vibration miss test

5. External dielectric coatings

6. Internal suppression diode not conforming to the screening requirements of JANS MIL-PRF-19500 and this specification

7. Coil wires finer than #44 AWG not continuously monitored during thermal shock

2.10 Resistors

2.10.1 Prohibited Resistors

1. All hollow glass or hollow ceramic core devices

2. Unpassivated Nicrome film resistors

3. All hermetic hollow ceramic core film resistors with internal metallization

2.10.2 Reliability Suspect Resistors

1. Carbon composition
2. Variable resistors
3. Nonwelded networks

2.11 Switches

2.11.1 Reliability Suspect Switches

1. Nonhermetic units
2. Noncorrosion resistant materials
3. Slide devices

2.12 Thyristors

2.12.1 Reliability Suspect Thyristors

1. All plastic encapsulated types
2. Nonglassivated or nonpassivated semiconductor devices without PMPCA approval
3. Devices with gold/aluminum bonds at the die

2.13 Transistors

2.13.1 Reliability Suspect Transistors

1. Nonglassivated or nonpassivated semiconductor
2. Devices with gold/aluminum bonds at the die

2.14 Wire

2.14.1 Reliability Suspect Wire Construction

1. Teflon (PTFE) insulated wire in general, though there are specific configurations and applications where PTFE insulated wires are prohibited (see below)
2. FN- or HN-grade polyimide (Kapton) insulated wire
3. Polyalkene insulated wire
4. Polyvinylidene fluoride (PVF2) (Kynar) insulated wire

5. NEMA-WC27500 unshielded-unjacketed cables with four or fewer conductors without 100% wire to wire 1500VAC Dielectric Withstanding Voltage (DWV) for wire rated up to 600V and 2500VAC for wire rated to 1000V to screen out the wire insulation flaws introduced during the cabling manufacturing

2.14.2 Prohibited Wire Construction

1. MIL-DTL-16878 wire types
2. All polyvinyl chloride (PVC) insulated wire and cable
3. SAE-AS22759 wire with only one PTFE layer
4. MIL-W-76 wire
5. Aluminum wire or cable
6. Pure tin-plated wire and braid except as allowed by Section 4, General Requirements, para 4.3.3.1 of this document
7. Teflon (PTFE) insulated wires in applications that have a high probability of producing cold flow of the insulation
8. MIL-DTL-81381 wire
9. MIL-W-81044 or SAE-AS81044 wire
10. Teflon insulated wire
11. Uninsulated Ag-plated Cu wire

3. Prohibited Nonelectronic Parts

3.1 Prohibited Attach Hardware

1. B-nuts used with flared tubing

Appendix G. Electronic Piece Part Derating Criteria

CONTENTS

General Considerations

The derating tables for all commodity types shall be adjusted for lower than MIL-SPEC temperature part ratings and Tg (glass transition temperature) for the plastic parts as appropriate based on the manufacturer maximum operating ratings.

Unless otherwise modified by the contract, all temperature calculations shall be based on component (box-level) acceptance temperature. The contractor shall also verify that parts are not overstressed (i.e., maximum operating conditions are not violated) under the box-level qualification environments.

All deviations from the derating criteria herein shall be approved by the PMPCA.

1. Capacitors

The derating tables and figures are only applicable for capacitors rated –55°C to 125°C operating temperature range. Use of lower-rated capacitors shall require special derating criteria and PMPCA approval on a PAR.

1.1 Military Specification Capacitor Types

Table 1-1. Capacitors, Mil-Spec Listing (for Reference)

Dielectric Material	MIL-SPEC	Style
Ceramic	MIL-PRF-39014	CKR
Ceramic	MIL-PRF-20	CCR
Ceramic	MIL- PRF -123	CKS
Ceramic, high voltage	MIL- PRF -20	---
Ceramic chip	MIL- PRF -55681	CDR
Mica	MIL- PRF -87164	CMS
Glass, porcelain	MIL- PRF -23269	CYR
Supermetallized film	MIL- PRF -83421	CRH
Supermetallized film (low-energy application)	MIL- PRF 87217	CHS
Plastic film; metallized and nonmetallized	MIL- PRF -19978	CQR
Tantalum foil	MIL- PRF -39006	CLR
Solid tantalum	MIL- PRF -39003	CSR
Solid tantalum, low impedance applications	MIL- PRF -39003/10	CSS
Solid tantalum chip	MIL- PRF -55365	CWR
Variable, glass or ceramic	MIL- PRF -14409 1/	---
Wet wet-tantalum	MIL- PRF -39006/22 2/	CLR79

NOTES:

1/ Variable capacitors are considered reliability suspect and cannot be used without PMPCA review and approval. Their design is such that they are nonhermetic, easily damaged by excessive installation soldering, and have a limited adjustment life.

2/ Only tantalum-tantalum construction (style CLR79) manufactured by a QPL/QML source with a double seal is approved for wet tantalum construction in expendable launch vehicle applications.

1.2 Requirements

The normal maximum operating temperature for all capacitors shall not be greater than shown in the derating curves for the applied stress or 10°C less than maximum rated temperature, whichever is less. The longevity and reliability of capacitors are increased by operation below their rated temperature limits and below their rated voltage, both AC and DC. The capacitor derating shall be in accordance with Table 1-2 and Figures 1-1 through 1-3.

Table 1-2. Capacitor Derating and Maximum Stress Ratios

Type	**MIL-SPEC Reference**	**Parameter**	**Maximum Stress Ratio (Nominal Operation)**	**Maximum Stress Ratio (Worst Case Operation)**
Ceramic		Voltage	0.50 of rated voltage 4/	0.70 WC 5/ (WC: Worst Case)
Ceramic chip		Voltage	0.50 of rated voltage 4/	0.65 WC 5/
Feed through capacitor		See EMI filters	__	__
Glass		Voltage	Figure 1-1	__
Supermetallized film CRH		Voltage	0.50 to 85°C max. 9/	0.65 WC to 85°C max.
Supermetallized film, and nonmetallized film CHS, CQR		Voltage	0.50 to 85°C max. 9/	0.65 WC to 85°C max. 6/
Mica		Voltage	Figure 1-1 Region I	Figure 1-1 Region I 1/
Porcelain		Voltage	Figure 1-1 Region I	Figure 1-1 Region I 1/
Tantalum solid 1/		Voltage	Figure 1-2 Region I	Figure 1-2 Region I 1/ and 7/
Solid tantalum chip 1/		Voltage	Figure 1-2 Region I 8/	Figure 1-2 Region I 1/
Wet tantalum-tantalum		Voltage	Figure 1-3 Region I	Figure 1-3 Region II 2/
Variable		Voltage	0.5	0.70 3/

NOTES:
1/ At least 0.1 ohms (Ω)/volt (V) for Region I and 0.3 Ω/V for Region II series resistance or equivalent current limit of 10 amps and 3 amps, respectively, shall be provided for solid tantalum and tantalum chip capacitors. Parallel tantalum capacitors do not require separate series resistors for each capacitor.
2/ Temperature rise due to ripple current shall not result in an operating temperature exceeding 85°C.
3/ Use only after PMPCA review and approval
4/ For nominal conditions, derate to 0.5 of rated voltage to 85°C, decreasing linearly to 0.30 of rated voltage at +125°C
5/ For worst case conditions, derate to 0.70 of rated voltage to 85°C, decreasing linearly to 0.50 of rated voltage at +125°C
6/ Linearly decrease voltage to zero at 100°C
7/ Special assembly and test procedures are required to ensure that tantalum capacitors are installed in accordance with the correct polarity.
8/ The maximum surge voltage shall not exceed the steady state rated voltage.
9/ Use only hermetic supermetallized film capacitors

1.3 Use of Derating Curves (Figures 1-1 through 1-4)

To determine the maximum permitted operating voltage from the following figures:

1. Determine the maximum part temperature at the location where the capacitor will be mounted. The maximum temperature is the sum of the part ambient temperature, which is the acceptance test temperature plus the temperature rise from the component baseplate to the part location, and the part operational temperature, which is a function of the applied voltage.
2. Find the maximum temperature on the x-axis, and read the voltage stress ratio upper limit from the Region I curve. The voltage stress ratio is determined by dividing the maximum voltage across the capacitor in its intended circuit application by the manufacturer's maximum voltage rating.
3. Any combination of part temperature and voltage stress ratio that lies in Region I shall be considered approved for that application. Any combination that lies in Region III shall be considered disapproved for the intended application. Combinations falling in Region II shall be identified, analyzed to assure that the part application meets mission requirements, and presented to the PMPCA for approval.

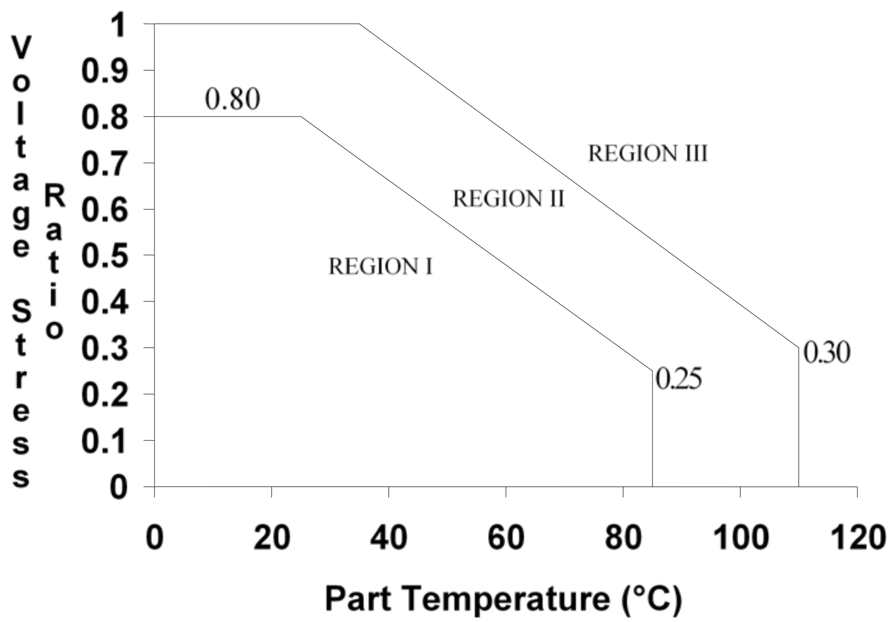

Figure 1-1. Glass, porcelain (CYR), mica (CMS).

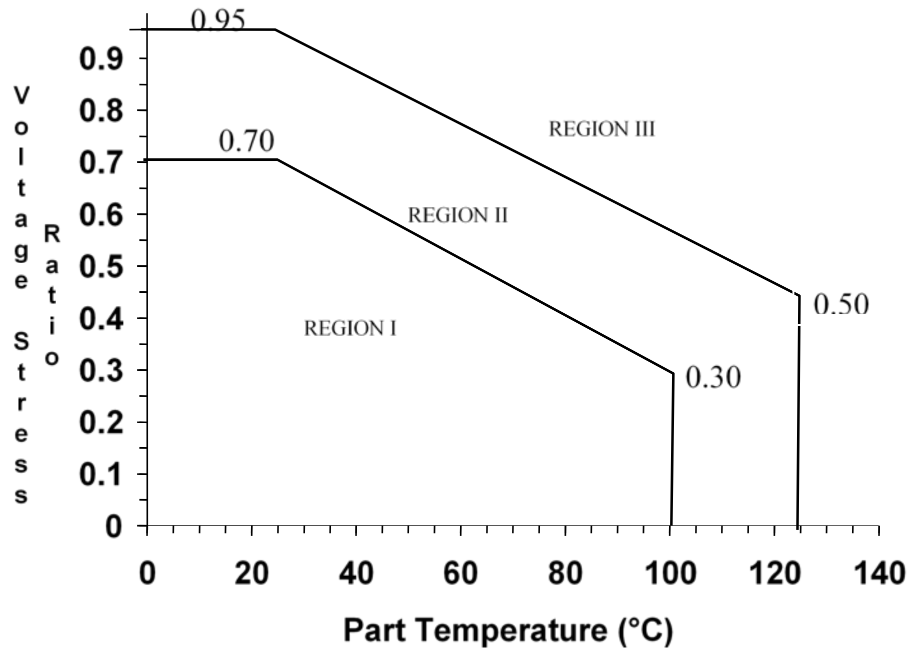

Figure 1-2. Solid tantalum (CSR, CSS, CWR).

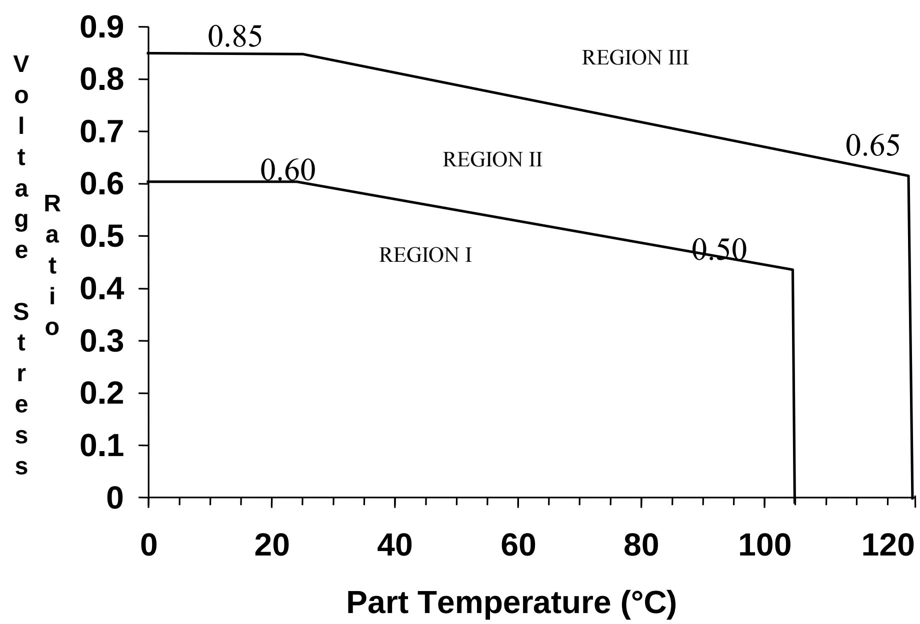

Figure 1-3. Wet tantalum (CLR79).

2. Connectors

The connectors derating shall be per Table 2-1 and Table 2-2.

Table 2-1. Connectors Deratings

Type	Parameter	Maximum Stress Ratio	Comments 1/, 2/, 3/
ALL	Current	0.50 of rating	When pins are connected in parallel to increase current capacity, each pin shall have the capability of conducting (within the derating criteria) 25% more current than the calculated equally-divided current to compensate for "current inbalance."
	Voltage	0.50 of rating	The maximum voltage stress ratio derating shall be multiplied by the sea level rated working voltage to obtain the maximum voltage to be applied between the pin and the case. This provides a safe working voltage for high altitude or space applications.
	Temperature	Not to exceed: T(max-dielectric) - 50°C	The maximum hot spot temperature shall be at least 50°C below the maximum rated temperature of the connector dielectric material.

NOTES:
1/ Within the constraints of this table, use Table 2-2 contact and wire sizes for current derating.
2/ For block connectors and crimp connections, the current derating is the same as Table 17-1 for the single wire.
3/ Power connector and return contact lines shall be separated by at least one unassigned connector pin to reduce short circuit risk.

Table 2-2. Connector Maximum Derated Current for Contact (AMPS)

Number of Contacts Used in the Connector	Contact Size	Maximum Derated Current (AMPS) for Contact Wire Size (AWG) 1/						
		16	18	20	22	24	26	28
1 to 4	16 20 22	13.0	9.2	6.5 6.0	 4.5 4.5	 3.3 3.3	 2.5	 1.8
5 to 14	16 20 22	9.0	7.0	5.0 5.0	 3.5 3.5	 2.7 2.7	 1.9	 1.4
15 or more	16 20 22	6.5	5.0	3.7 3.7	 2.5 2.5	 2.0 2.0	 1.4	 1.0

NOTES:
1/ Connector derating shall also comply with the "per pin" derating of Table 2-1.
2/ Maximum voltage = 50% of the rated sea level dielectric withstanding voltage (DWV) between the pin and the case for all contact sizes.

3. Crystals

Crystals and crystal oscillators shall be derated per Table 3-1.

Table 3-1. Crystals, Crystal Oscillators

Type	Parameter	Maximum Stress Ratio	Comments
Crystals	Current (drive level)	0.50	50% drive current equals 25% drive power.
Crystal oscillator			1/

1/ Derating shall be accomplished by applying derating as specified herein for the discrete parts contained in the oscillator.

4. Diodes

Diode derating shall be per Tables 4-1 through 4-7.

Table 4-1. Diode (Switching, Small Signal, Rectifier, and Transient Suppressors)

Parameter	Maximum Stress Ratio		
	Switching, Small Signal	**Rectifier**	**Transient Suppressor**
Power	0.50 (0.70 WC) 2/	0.65 (0.70 WC) 2/	0.75
Voltage, DC or repetitive pulse	0.75 2/	0.75 2/	----
Voltage transients 1/	0.80 2/	0.80 2/	0.75
Forward current	0.50 2/	0.75 (0.85 WC) 2/	---
Surge current	0.50 2/	0.75 (0.85 WC) 3/	---
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 4/	125°C, or 20°C less than the manufacturer's operating temperature rating 4/	125°C, or 20°C less than the manufacturer's operating temperature rating 4/

NOTES:
1/ Worst case turn-on or repetitive transient
2/ Of maximum rating
3/ Of surge rating
4/ Whichever is lower

Table 4-2. Diode
(Step Recovery, Varactor, and Varicap)

Parameter	**Maximum Stress Ratio**
Power	0.50 (0.70 WC)
Voltage, DC or repetitive pulse	0.75 2/
Voltage transients 1/	0.80 2/
Forward current	0.75 2/
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 3/

Table 4-3. Zener Diode
(Reference and Regulator)

Parameter	**Maximum Stress Ratio**
Reference Zener	
Power	0.50 (0.85 WC) 2/
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 3/, 4/, and 5/
Regulator Zener	
Power	0.50 (0.75 WC) 2/, 5/
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 3/, 5/

NOTES FOR TABLES 4-2 AND 4-3:

1/ Worst case turn-on or repetitive transient

2/ Of maximum rating

3/ Whichever is lower

4/ Note that temperature-compensated reference diodes must be operated at the manufacturer's specified current to optimize temperature compensation.

5/ The zener current shall be limited to no more than $I_Z = I_{Z\ nominal} + .05\ (I_{Z\ maximum} - I_{Z\ nominal})$ but do not derate to the point where the device is operating at the knee.

Table 4-4. Diode, Schottky Barrier

Parameter	Maximum Stress Ratio
Power	0.75 (0.85 WC)
Voltage, DC or repetitive pulse	0.75 2/
Voltage transients 1/	0.80 2/
Surge Current	0.50
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 3/

Table 4-5. Diode (Tunnel, Germanium) 3/

Parameter	Maximum Stress Ratio
Power	0.50 (0.70 WC)
Voltage, DC or repetitive pulse	0.70 2/
Voltage transients	0.80 2/
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 3/

NOTES FOR TABLES 4-4 AND 4-5:
1/ Worst case turn-on or repetitive transient
2/ Of maximum rating
3/ Whichever is lower
4/ Germanium diodes are not recommended for new or modified designs.

Table 4-6. Diode (Photo, Led, Optocouplers 1/)

Parameter	Maximum Stress Ratio
Power	0.50
Current	0.50 (0.70 WC)
Voltage	0.75
Junction temperatur	125°C, or 20°C less than the manufacturer's operating temperature rating 2/

NOTES:
1/ For optimum coupling efficiency, use manufacturer's recommended operating conditions
2/ Whichever is lower

Table 4-7. Diode (FET Regulator)

Parameter	Maximum Stress Ratio
Current	0.80
Junction temperature	125°C, or 20°C less than the manufacturer's operating temperature rating 1/

NOTES:
1/ Whichever is lower

5. EMI Filters

EMI filters shall be derated per Table 5-1. The derating is only applicable for EMI filters rated –55°C to +125°C operating temperature range. Use of lower-rated EMI filters shall require special derating criteria and PMPCA approval on a PAR.

Table 5-1. EMI Filters

Type	Parameter	Maximum Stress Ratio
ALL	Voltage	0.50 of rating
	Current	0.75 of rating
	Temperature	Operating case temperature 85°C maximum

6. Fuses

Fuses shall be derated per Table 6-1 and Figure 6-1. The derating table and figure are only applicable for fuses rated –55°C to +125°C operating temperature range. Use of lower-rated fuses shall require special derating criteria and PMPCA approval on a PAR.

Table 6-1. Fuse Derating

Type	**Parameter**	**Maximum Stress Ratio**	**Comments 1/, 2/**
Solid body	Current	0.75 of rating	Multiply 0.75 by the additional derating of Figure 6-1 to compensate for temperature.
Glass fuses 1/ 1/8 amp 2/ 1/4 amp 2/ 3/8 amp 2/ 1/2 amp 2/ 1 amp 2 amp or greater	Current Current Current Current Current Current	0.25 of rating 0.30 of rating 0.35 or rating 0.40 of rating 0.45 of rating 0.50 of rating	Manufacturer's current ratings are temperature dependent. Derating factors are based on data from fuses mounted on printed circuit boards and conformal coated. The derating criteria allows for possible loss of pressure which lowers the blow current rating and allows for a decrease of current capability with time.
Fusible resistors	Current	Consult Reliability Engineering	Above 25°C, the derating factor decreases an additional 0.5% for each degree C above 25°C. In the event a nonstandard fuse size is required, use the next higher-rated fuse size.

NOTES:
1/ Glass fuses are derated for reliability and to allow for air loss in a vacuum.
2/ Shall not be used on new or modified designs without PMPCA approval.

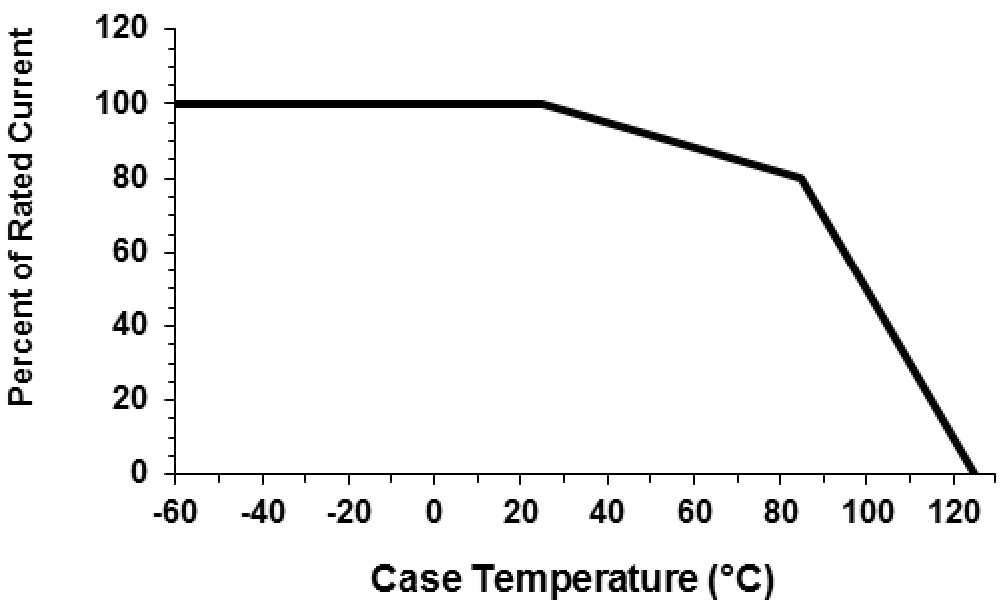

Figure 6-1. Solid body fuse additional derating for temperature.

7. Inductors and Transformers

Iductors and transformers shall be derated per Table 7-1.

Table 7-1. Inductors and Transformers

Type	Parameter	Maximum Stress Ratio	Comments 1/, 2/, 3/
All	Current	0.50 of rating	2/
	Voltage	0.50 of rating	**Inductors:** As established, per MIL-PRF-39010, MIL-PRF-27, or MIL-PRF-21038, as applicable, for dielectric withstanding voltage (DWV), induced voltage, and corona voltage **Transformers:** As established per MIL-PRF-27 or MIL- PRF-21038 for DWV, induced voltage, and corona voltage.
	Temperature (inductors)	1/ and 4/	Classes per MIL-PRF-39010 or MIL-PRF-27 as appropriate. 3/
	Temperature (transformers)	1/ and 5/	Classes per MIL-PRF-27 or MIL-PRF-21038 as appropriate. 3/

NOTES:

1/ Insulation rated at less than 150°C shall not be used. The maximum operating temperature of the device shall be at least 30°C lower than the maximum temperature of the item with the lowest maximum temperature. This may be the core material, the insulation of the magnet, etc.

2/ Current rating for each winding shall be less than or equal to the rating for a bundle of wires of the same AWG size as the wire used for the winding (see Table 17-1 Wire Derating).

3/ The permitted maximum temperature stress is defined as the worst case temperature resulting from the combined effects of hot spot temperature, the ambient and/or base plate temperature, and the temperature rise resulting from joule heating.

4/ Maximum operating temperature equals ambient temperature plus temperature rise +10°C (allowance for hot spot). Compute temperature rise as follows:

Inductor temperature rise (°C) = ((R-r)/r)(T+234.5*)

Where:

R = winding resistance under load**

r = no-load winding resistance at ambient temperature T (°C)

T = maximum ambient temperature (°C) at time of power shutoff

5/ Maximum operating temperature equals ambient temperature plus temperature rise + 10°C (allowance for hot spot). Compute temperature rise as follows:

Transformer temperature rise (°C) = ((R-r)/r)(t+234.5*)-(T-t)

Where:

R = winding resistance under load**

r = no-load winding resistance at ambient temperature T (°C)

t = specified initial ambient temperature (°C)

T = maximum ambient temperature (°C) at time of power shutoff. (T) shall not differ from (t) by more than +5°C.

* This factor is for copper wire, but varies for different wire materials

** For accurate results, this measurement must be made in a vacuum to simulate actual operating conditions.

Need to match 5236 derating criteria

8. Integrated Circuits

8.1 Derating Criteria for Integrated Circuits

Integrated circuits (IC) shall be derated per Table 8-1 through 8-3.

Table 8-1. Integrated Circuit, CMOS, TTL

Parameter	**Maximum Stress Ratio**	**Comments**
Voltage, input	0.70 (May not exceed supply voltage applied to IC)	1/
Voltage, supply DIGITAL turn on operational	Transient peaks shall not exceed the absolute maximum value. Per manufacturer's recommended operational voltages	
Fanout	Derate by one load or to 80% (90% WC) of maximum rating, whichever is greater.	Not applicable to single fanout devices.
Current, load	0.80 (0.90 WC) 2/	Not applicable to single fanout devices.
Propagation delay	1.1	Worst case only
Power dissipation (if applicable)	0.80 (0.90 WC)	
Open collector/ drain output voltage	0.75	
Junction or hot spot temperature	125°C, or 20°C less than the manufacturer's operating temperature rating	Whichever is lower

NOTES:

1/ For parts that are designed to accept an input voltage that is greater that the IC supply voltage, the maximum stress shall be 25% or more below the part manufacturer's maximum specified rating.

2/ The derating for all outputs of digital devices shall be calculated for both high and low output states.

Table 8-2. Integrated Circuit, Linear, Op Amp, Comparator 1/

Parameter	Maximum Stress Ratio	Comments
Power	0.70 (0.85 WC)	
Voltage, input	0.70 (0.80 WC) of maximum rating	2/
Operating frequency (applications)	0.75 (0.85 WC) of maximum rating	
Transients	Transient peaks shall not exceed the absolute maximum value.	
Gain (applications)	0.75 (0.85 WC) of maximum rating	
Voltage, supply	0.90 of maximum rating	Not to exceed the manufacturer's recommended operating voltage in WC.
Current, output	0.75 (0.85 WC) of maximum rating	Of rated value, or 0.75 of the current limited value.
Junction or hot spot temperature	125°C, or 20°C less than the manufacturer's operating temperature rating.	Whichever is lower

NOTES:

1/ In general, the 10% minimum/maximum margin applies to operational characteristics for the device, such as usable gain bandwidth, propagation delay, etc.

2/ Of the maximum rated supply voltage applied to the IC and/or of the rated differential input voltage. The input voltage shall not exceed the applied supply voltage.

Table 8-3. Integrated Circuit, Linear Voltage Regulator

Parameter	Maximum Stress Ratio	Comments
Power	0.80 (0.85 WC)	The controlling factor for
Voltage, input	0.80 (0.85 WC)	Voltage regulators is the input-output voltage differential Which shall be limited to 80% of the maximum rated (Vin-Vout).
Current, input	0.80 (0.90 WC)	
Current, output	0.75 (0.85 WC)	
Transients	Transient peaks shall not exceed absolute maximum values	
Junction or hot spot temperature	125°C, or 20°C less than manufacturer's operating temperature rating	Whichever is lower

8.2 Hybrid Chip and Wire

8.2.1 Derating Criteria for Hybrid Chip and Wire Devices

8.2.1.1 Internal Elements Derating

Electrical stress: Each hybrid element shall be derated for electrical stress (e.g., voltage, current, power) in accordance with the element's technical section of this document (i.e., microcircuits shall be derated per Section 900, semiconductors shall be derated per Section 1400, solid tantalum capacitors shall be derated per Section 270, etc.), except for resistors, where derating to zero power shall occur at the maximum rated temperature of the part as specified in the applicable MIL-SPEC or SCD.

Temperature stress: Hybrid elements shall be derated for temperature such that when the hybrid is operated at its maximum operating temperature during burn-in or life test, the active elements shall not exceed 90% of their manufacturers' maximum temperature ratings, and passive elements shall not exceed 3°C above their military-specification maximum rated operating temperature.

8.2.2 Hybrid Derating

Temperature: Hybrids shall be derated from their maximum rated operating temperature as follows:

Nominal conditions: Tj Max. = 80% of maximum rated Tj or 105°C, whichever is less

Worst case conditions: Tj Max. = 90% of maximum rated Tj or 125°C, whichever is less

At no time during powered testing shall the hybrid be operated above its maximum rated operating temperature or 125°C, whichever is less.

8.2.3 Internal Wire

Maximum design current for any given internal wire or ribbon used in a hybrid microcircuit is dependent upon the conductor material and the wire diameter and is equal to 50% of the value determined by the equation $I=Kd^{3/2}$. The constant (K) is dependent upon the composition of the wire or ribbon as shown.

Table 8-4. Values for K

Conductor Material	**K Values for Conductor Length (L)**	
	$L \leq 0.040"$	$L > 0.040"$
Aluminum	22,000	15,200
Gold	30,000	20,500
Copper	30,000	20,500
Silver	15,000	10,500
All others	9,000	6,300

8.3 Derating Criteria (Integrated Circuits, Other)

For large scale integrated circuits, microcircuit chips for hybrids, and integrated circuit part types not specifically addressed in the preceding material, appropriate linear and/or digital criteria from the appropriate derating tables shall apply. For devices which are partially digital and partially linear, the linear device derating factors shall apply to the linear portion of the device and the digital device derating factors shall apply to the digital portion.

9. Motors

The motors shall be derated per Table 9-1.

Table 9-1. Motor Derating

<u>TEMPERATURE</u> Motor parts and materials shall be subject to the same temperature restrictions as inductors. Specifically: 1. Maximum temperature (hot spot, ambient + temperature rise) Class A, 105°C, and Class B, 125°C; classes per MIL-PRF-15305. 2. Insulation rated at less than 105°C shall not be used. No part or material shall operate at a temperature greater than 30°C below the manufacturer's rated temperature for the part or material.
<u>BEARING LOAD</u>: 75% maximum of rated value. Note that motor loading directly affects electrical stress and lifetime. Motor loading at operating speed shall be sufficiently derated from maximum rated torque so as to comply with the above temperature guidelines.
<u>WIRE</u> Restrictions on wire size shall apply to motor windings and leads. (See Table 17-1.)
<u>LIFETIME DERATING</u> Motor lifetime in space applications will be determined by such factors as bearing lubrication, motor loading, and electrical stress. These factors shall be derated to 25% or less of their predicted capability under the application conditions.

10. Printed Wiring Boards

10.1 Derating Criteria

The derating criteria shall be per IPC-2221 Class 3 and as further defined in IPC-2152 Class 3.

11. Relays

THE RELAYS SHALL BE DERATED PER TABLE 11-1. The derating table is only applicable for relays rated –55°C to +125°C operating temperature range. Use of lower rated relays shall require special derating criteria and PMPCA approval on a PAR.

Table 11-1. Relay Derating (See Notes 1/ through 8/)

Relay Load Type	Contact Current Maximum Stress	Coil Voltage	
		Minimum Allowable	**Maximum Allowable**
Resistive	0.75 of resistive load rating	1.1 of must-operate voltage at +125° C rating	0.9 of maximum rated voltage
Inductive	0.50 of inductive load rating, or 0.40 of resistive load rating if inductive load rating is not specified	1.1 of must-operate voltage at +125°C rating	0.9 of maximum rated voltage
Motor	0.5 of motor load rating, or 0.20 of resistive load rating if motor load rating is not specified	1.1 of must-operate voltage at +125°C rating	0.9 of maximum rated voltage
Filament	0.10 of resistive load rating	1.1 of must-operate voltage at +125°C	0.9 of maximum rated voltage
Capacitive or in-rush type load	Series resistance shall be used with any capacitive load to insure that currents do not exceed derated levels for resistive loads.	1.1 of must-operate voltage at +125°C rating	0.9 of maximum rated voltage

NOTES:

1/ Maximum number of operations shall be 50% of rated life when relay is used with resistive loads, and 25% of rated life when used with inductive loads. Relay actuations performed during pre-flight testing shall be included as a portion of the permitted maximum number of relay operations.

2/ Suppression of induced transient voltage spikes is typically recommended to minimize effects on circuits/devices used to drive relay coils. Back-to-back zener diodes, or a zener diode with a blocking diode, across the coil are effective techniques. These techniques minimize degradation to contact life which can occur because of longer drop-out times for the suppressed coil. Bifilar wound coils are another option. If used, they should not require additional external suppression.

3/ For loads other than those specified in the above table, the stress on the relay contacts shall be no greater than 75% of the manufacturer's rating for the type of load specified.

4/ Contacts can be paralleled for redundancy. However, paralleled contacts shall not be used as a means to increase contact current rating over the value specified for a single current. This restriction is necessary because there is no guarantee that parallel contacts will open and close simultaneously. Therefore, a single contact must be capable or carrying the entire load.

5/ Relays used to switch resistive loads at an appreciable distance from the relay contacts (such as in a spacecraft harness) may, in fact, be switching a load with significant inductance (the harness) in series with the load resistance. Each case shall be examined separately to determine the amount of inductance. If the amount of inductance as defined by the equation $L=.0001R_L$ in MIL-R-6106 is exceeded, the relay contact load shall be considered to be inductive. In these cases, the contacts shall be derated using the inductive derating rather than the resistive derating.

NOTES (continued)

6/ Arc suppression techniques for the relay contacts are not recommended for use in spacecraft designs to provide higher than the derated current value in Table 11-1, since failure of the arc suppression circuit increases the risk of relay contact failure. Instead, relay contacts of a higher rating that can withstand the surge current during switching should be used.

7/ Relay contacts can safely carry more current than they can switch. For purposes of derating, the “carry-only” load shall not exceed 90% of the rated “carry-only” load.

8/ Relay coil voltages should not be derated. Relay coils should be operated at their specified nominal voltage level. Since operation exactly at the specified nominal voltage is not always possible. There are some upper and lower tolerance limits for coil voltage. Table 11-1 defines those limits which will ensure proper relay operation. The minimum actuation voltage supplied to the relay coil should never be less than 110% of the smallest voltage which will operate the relay at its maximum related temperature. The voltage supplied to the coil should never be greater than 90% of the specified maximum voltage rating for the coil over the specified temperature range.

12. Resistors

Table 12-1. MIL-SPEC Listing (For Reference)

Resistor Type	**MIL-SPEC**	**Style**
Fixed, carbon (insulated) composition	MIL-R-39008	RCR
Fixed film (insulated)	MIL-PRF-39017	RLR
Fixed film resistor chips	MIL-PRF-55342	RM, RMO
Fixed film	MIL-PRF-55182	RNC
Fixed film, precision	MIL-PRF-55182	RNR 1/
Fixed film, high voltage	MIL-PRF-55182	
Fixed, wire wound (accurate)	MIL-PRF-39005	RBR
Fixed, wire wound (PWR type)	MIL-PRF-39007	RWR
Fixed, wire wound power type chassis mounted	MIL-PRF-39009	RER
Resistance network	MIL-PRF-83401	RZ, RZO
Thermistor	MIL-PRF-23648	RTH
Variable, nonwire wound 2/ (adjustment type)	MIL-PRF-39035	RJR
Variable, nonwire wound (2) (lead screw actuated)	MIL-PRF-39015	RTR

NOTES:
1/ For solder only applications, not for welding.
2/ Not recommended for space usage.

THE RESISTORS SHALL BE DERATED PER TABLE 12-2 AND FIGURES 12-1 THROUGH 12-5. The derating tables and figures are only applicable for the referenced Table 12-1 MIL-SPEC designs. Use of lower rated designs shall require special derating criteria and PMPCA approval on a PAR.

Table 12-2. Resistor Derating

Type	**MIL-SPEC-**	**Parameter**	**Maximum Stress Ratio 11/**
Carbon composition	MIL-R-39008	Power	Figure 12-1 1/
Metal film RLR RNC	MIL-PRF-39017	Power Power	Figure 12-2 1/ Figure 12-3 1/
Film, chip - RMO		Power	0.50 (0.75 WC) 2/ and 9/
Film resistance network		Power	0.50 (0.75 WC) 2/ and 9/
Wire wound accurate - RBR		Power	Figure 12-4 1/, 8/, and 10/
Wire wound power - RWR		Power	Figure 12-5 1/ and 4/
Wire wound power – RER chassis mounted		Power	Figure 12-5 1/ and 4/
Deposited (thick film as part of a hybrid substrate)		Power	0.50 3/
Inconel foil heaters or deposited heaters on Kapton		Power	0.50 6/
Thermistors positive temperature compensating		Power	0.50
Thermistors negative temperature compensating		Power	0.50 5/
Microwave loads, isolators, circulators (pill resistors)		Power	0.50 7/

NOTES:

1/ For discrete resistors, the voltage shall not exceed 50% of rated voltage. Where a specific voltage rating has not been stated, the nominal rated voltage shall be determined from E = square root of (PR). When the voltage is applied in short pulses so that the average power of the resistor is less than 50% of the manufacturer's rating, this voltage derating may be the controlling derating factor.

Average pulse power is defined by:

$$P_{average} = P(t/T)$$

Where

P = pulse power, calculated from E^2/R
E = amplitude of the pulses
R = impedance across which the pulses appear
t = pulse width or duration in seconds
T = cycle width or duration in seconds

For nonrepetitive pulses, the resistor's thermal time constant in the particular application shall be determined and the pulse power limited to a value that does not result in a temperature rise at the resistor surface which is greater than the temperature rise that would result from the applied derated DC power level.

NOTES (continued)

2/ Power rating shall be determined from the maximum hot spot temperature and a calculation of the thermal resistance from the element to the equipment mounting surface. For nominal operation (Region I) and worst case (Region II), derate to 0.5 of rated power and 0.75, respectively, up to 70°C. Above 70°C, linearly reduce the power derating factor to zero at +125°C.

3/ Deposited resistors: Dimensions are determined by required resistance value and the resistivity of the ink used. Power rating for DuPont Birox 1400 series inks is 100 watts per square inch. The total power dissipated on a substrate, however, shall not exceed 4 watts per square inch and the voltage shall not exceed 1500 volts per inch of length. Consult the appropriate specification for other inks.

4/ For chassis-mounted applications, resistor body temperature (hot spot) shall not exceed 140°C.

5/ Current limiting resistors or other methods shall be used to prevent thermal runaway. The 50% power stress ratio applies to +25°C. Derate linearly to zero milliwatts at +125°C (or the appropriate zero power temperature for the thermistor used).

6/ 50% derating applies only if low thermal resistance exists between the heater and the heatsink. Higher derating (dissipating less power) is required if there is no heat sink, or if the thermal resistance to the heat sink is not low.

7/ This is 50% of the manufacturer's maximum power rating for the component (such as a load that will still permit the circuit to function.

8/ These resistors are susceptible to absorption of water vapor and can exhibit a positive or negative (usually positive) shift of resistance of 30 to 70 parts per million.

9/ Under relatively low humidity conditions, film chip resistors (particularly those of smaller base size with high sheet resistance films) are subject to electrostatic discharge (ESD), sudden shifts in resistance, and in the temperature coefficient of resistance. Precautions against ESD are necessary in packaging and handling.

10/ The RBR resistors are designed as precision resistors. They are physically larger than RWR resistors for the same wattage rating which enables them to be used at higher power stress ratios than RWR resistors while maintaining their accuracy.

11/ The resistor derating guidelines account for the vacuum environment of space and are based on the maximum allowable resistor body hot spot temperature for lead-mounted resistors in a vacuum, except for RER and inconel foil heater resistors, which are based on chassis mounting.

12.1 Use of Derating Curves (Figures 12-1 through 12-5)

To determine the maximum permitted operating power from the following figures:

1. Determine the maximum temperature at the location where the resistor will be mounted. The maximum temperature is the sum of the part ambient temperature, which is the acceptance test temperature plus the temperature rise from the component baseplate to the part location, and the part operational temperature, which is a function of the power applied.

2. Find that maximum temperature on the x axis, and read the power stress ratio upper limit from the Region I curve. The power stress ratio is determined by dividing the maximum power across the resistor in its intended circuit application by the manufacturer's maximum power rating.

3. Any combination of part temperature and power stress ratio that lies in Region I shall be considered approved for that application. Any combination that lies in Region III shall be considered disapproved for the intended application. Combinations falling in Region II shall be identified, analyzed to assure that the part application meets mission requirements, and presented to the PMPCA for approval.

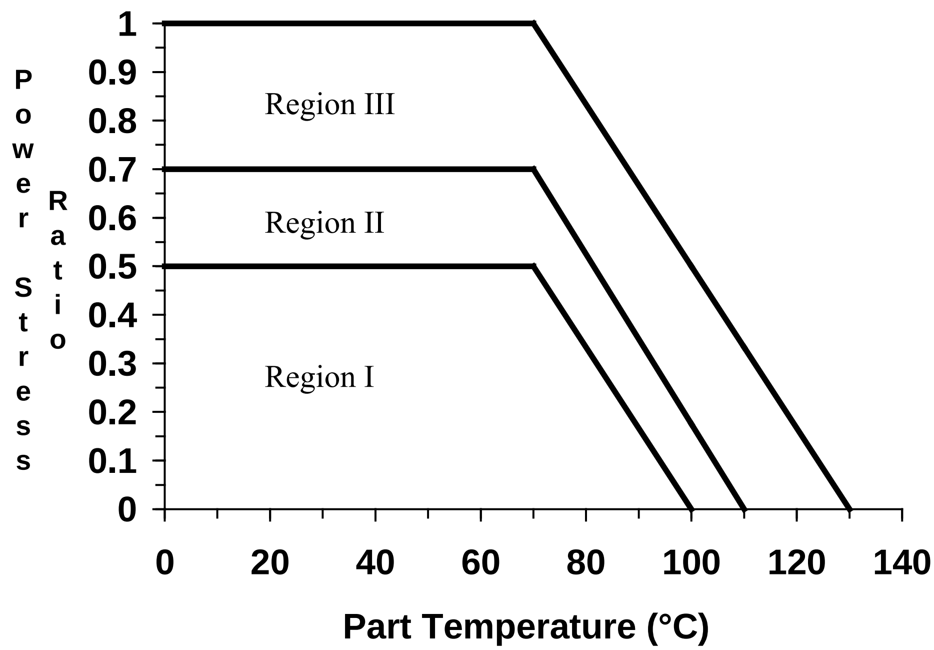

Figure 12-1. Carbon composition resistor (RCR).

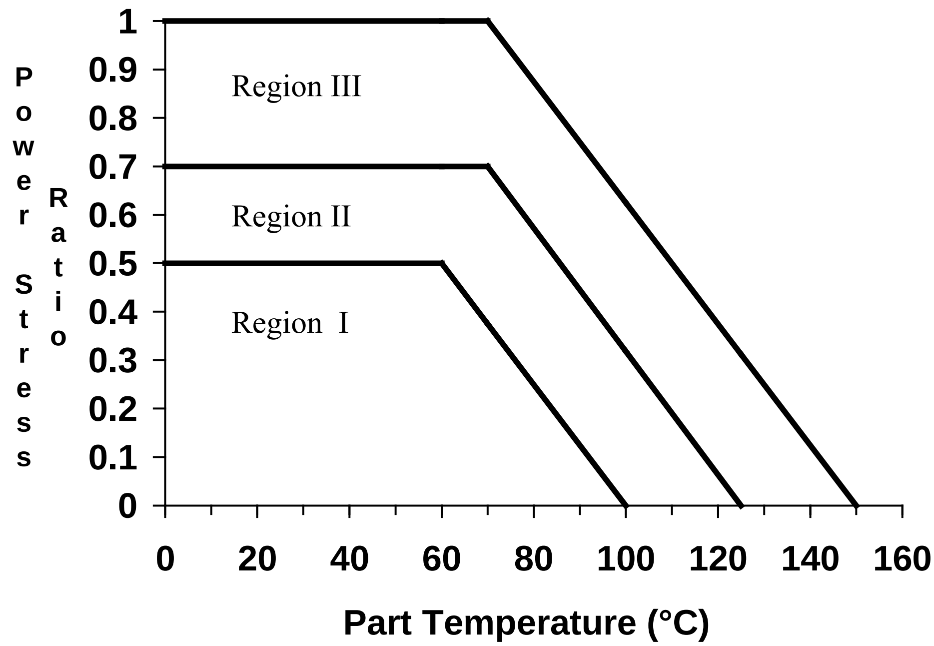

Figure 12-2. Metal film resistor (RLR).

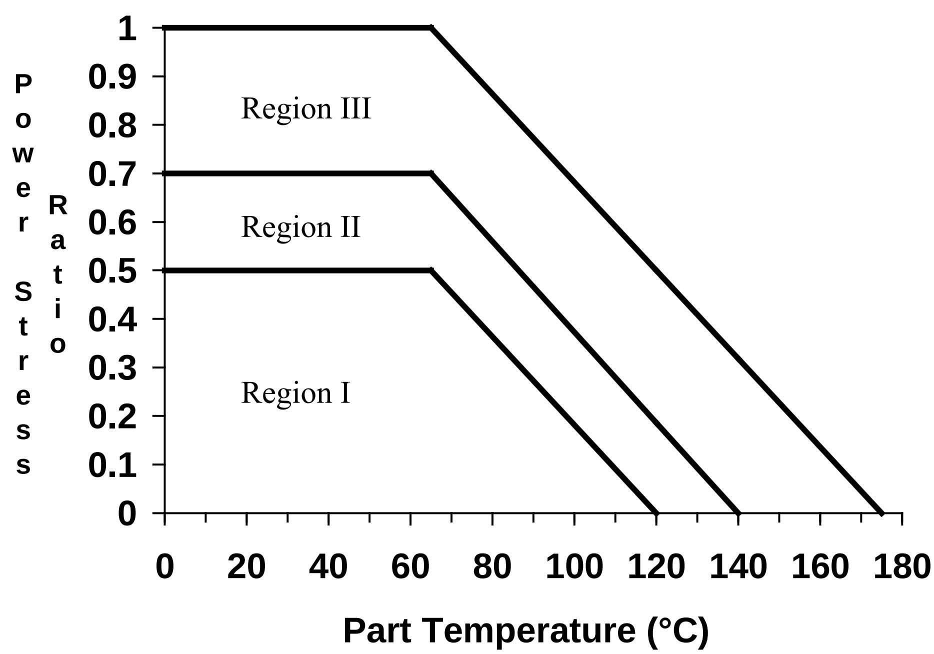

Figure 12-3. Metal film resistor (RNC, RNR).

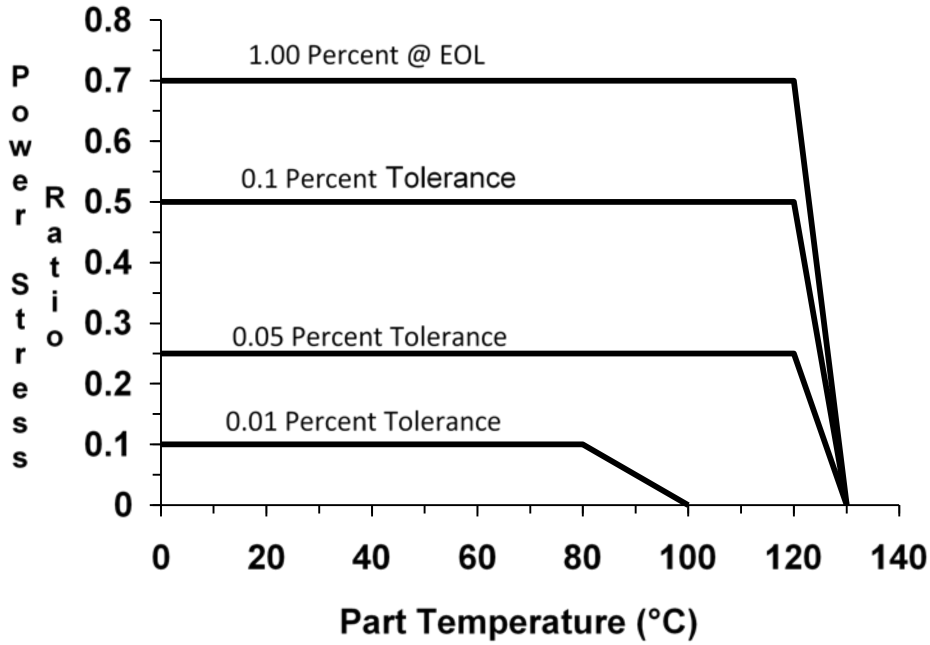

Figure 12-4. Wire wound accurate resistor (RBR).

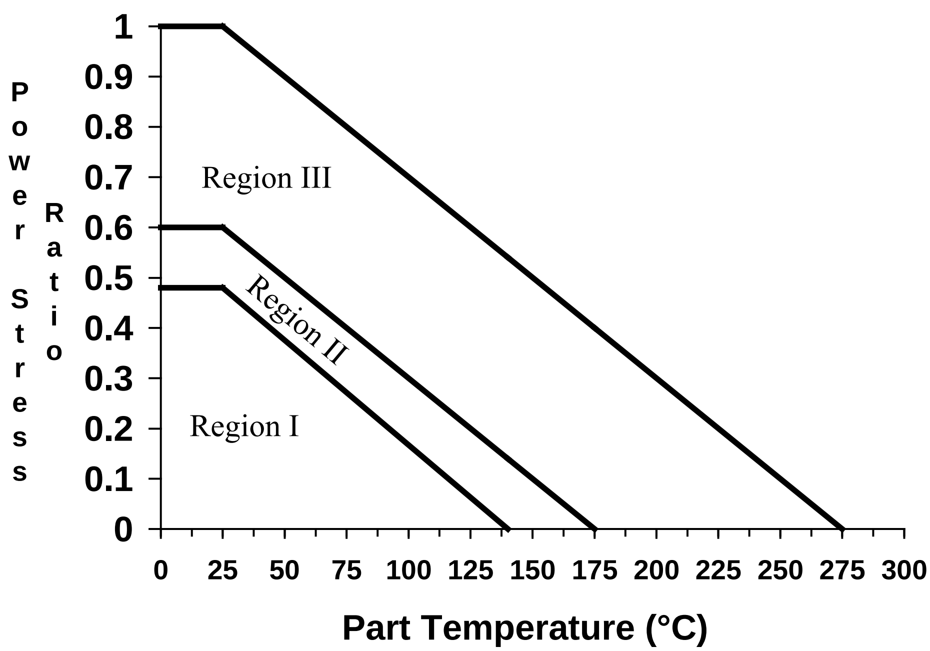

Figure 12-5. Wire wound power resistor (RWR, RER).

13. Slip Rings

13.1 Derating Criteria

The maximum current in the slip ring shall not exceed 50% of the designed current carrying capability of the slip ring. In addition, slip rings shall be designed so that when 50% of the rated current is being carried, the temperature rise of the slip rings shall not exceed 50°C rise above ambient.

14. Substrates

14.1 Derating Criteria

Alumina substrates shall be derated to 50% of the manufacturer's dielectric withstanding voltage.

15. Switches

15.1 Switch Derating Criteria

The derating requirements for electromechanical switches shall be the same as for relays. The notes below Table 11-1 that refer to relays also apply to switches. For solid state switches, use the semiconductor, integrated circuits, or hybrid derating criteria as applicable.

Thermal switches per MIL-PRF-24236 shall be derated as stated above and proper configurations of series and parallel redundancy shall be employed. In addition, a +4°C minimum dead band shall be required and a temperature rate of change equal to or greater than 0.11°C/minute shall be used. If these conditions cannot be met, solid-state thermal controls shall be used.

16. Transistors

Transistors shall be derated per Tables 16-1 through 16-3.

Table 16-1. Transistor, Bipolar, JFET

Parameter	Maximum Stress Ratio	Comments
Power	0.50 (0.60 WC) 1/	
Voltage	0.75 of maximum rating 2/	
Voltage transients	0.85 of maximum ratings	Worst case turn-on or repetitive transient
Current	0.75 (0.85 WC)	
Junction temperature	125°C, or 20°C less than the manufacturer's rating.	Whichever is lower

Table 16-2. Transistor, GAAS FET

Type	Parameter	Maximum Stress Ratio	Comments
GaAs FET low noise	Voltage current power, channel temperature, channel	0.75 0.75 3/ and 4/ 0.50 125°C, or 20°C less than the manufacturer's rating	Whichever is lower
GaAs FET power	Voltage current temperature, channel	0.75 0.75 3/ and 4/ 125°C, or 20°C less than the manufacturer's rating	Whichever is lower

Table 16-3. MOSFET, Small Signal and Power

Parameter	Maximum Stress Ratio	Comments
Voltage, gate to source, V_{GS}	0.75	
Channel power	0.50	
Channel current	0.75 3/ and 4/	
Breakdown voltage, V_{BGSS}	0.75	
Temperature, channel	125°C, or 20°C less than the manufacturer's rating	Whichever is lower

NOTES FOR TABLES 16-1, 16-2, and 16-3:

1/ Usable power at a given case temperature can be found from

$$P = (T_{Jmax} - T_C)/\phi_{JC}$$

where:

T_{Jmax} is the maximum allowed junction temperature
T_C is the device case temperature
ϕ_{JC} is the thermal resistance from junction to case

2/ Voltage derating applies to device voltages such as V_{CBO}, V_{EBO}, and V_{CEX}.

3/ Where maximum I_{DS} rating is not specified, the upper I_{DSS} rating will apply.

4/ Devices may be tested briefly with I_{DS} not to exceed the maximum rated value. Forward gate current shall be 0.90 or less of rating, or zero if not specified.

17. Wire and Cable

17.1 Derating Criteria

Wire shall be derated per Table 17-1.

Table 17-1. Wire Derating 1/, 2/

Wire Size AWG#	Maximum Applied Current (AMPS)		Comments
	Bundle/Cable	Single Wire	
30	0.7	1.3	Current ratings for bundles are based on bundles of 15 or more wires at 70°C in a hard vacuum. For smaller bundles the allowable current may be proportionally increased as the bundle approaches a single wire. Ratings are based on polyalkene insulated copper wire.
28	1.0	1.8	
26	1.4	2.5	
24	2.0	3.3	
22	2.5	4.5	
20	3.7	6.5	
18	5.0	9.2	
16	6.5	13.0	
14	8.5	19.0	
12	11.5	25.0	
10	16.5	33.0	
8	23.0	44.0	

NOTES:

1/ Use of wire smaller than AWG # 30 is not recommended. However, if wire smaller than AWG# 30 must be used, the maximum current rating for a single wire is 2.63 milliamps per circular mil (3.348 mA/sq. mil) of cross-sectional area. Wire smaller than AWG # 36 shall require reliability review and PMPCA approval prior to use and shall not be used in critical applications.

2/ The current in wires terminated in or run through connectors may be restricted further than indicated above by virtue of the connector contact size. See Section 2 Connectors, Tables 2-1 and 2-2.

Appendix H. General Sampling Plan

DELETED

Appendix I. Small Lot Sampling Plan or Custom Devices

DELETED

Appendix J. Radiation Hardness Assurance

1. Scope

This appendix provides the detailed performance requirements for managing the radiation hardness assurance of all units that comprise the launch vehicle.

2. Hardness Assurance Program

Contractor shall develop and implement a radiation tolerance assurance program for all units containing EEEE parts requiring some level of radiation tolerance, during the design and production of the launch vehicle. As part of the radiation tolerance assurance program, contractor shall perform the following tasks:

1. Determine the radiation tolerance assurance requirements that will ensure that the vehicle meets all applicable radiation requirements with adequate margin. These shall include mitigation of threats from single-event effects (SEE) (such as single-event latch-up, single-event burnout, single-event gate rupture, single-event dielectric rupture, single-event functional interrupt, single-event upset, and single-event transient) due to trapped protons, solar energetic particles (SEPs) and galactic cosmic rays (GCRs) during the mission lifetime.

2. Develop a radiation tolerance program plan to demonstrate satisfaction of the mission requirements with adequate margin, including the review, analysis, and reporting of any test results.

3. Assess residual risk from untested threats. Examples of untested threats include, but are not limited to, high-linear energy transfer (LET) GCRs or EEEE parts in untested electrical configurations.

4. Demonstrate the relevance of test data to flight units.

2.1 Hardness Assurance Requirements

Contractor shall assess all known radiation threats in the mission environment and shall determine the risk of mission failure from those radiation threats.

Contractor shall take into consideration the degree to which radiation hardness assurance and supply chain management techniques have been applied during procurement of all EEEE parts.

If radiation testing is performed as part of the radiation tolerance program plan, then the contractor shall carry out the following tasks:

1. Develop a detailed radiation test plan that demonstrates that test results will ensure that all units satisfy the mission requirements with adequate margin.

2. Execute and record the execution of the radiation tests, including test anomalies and variances from the test plan.

3. Generate test reports, including analysis of test results, to demonstrate that all mission requirements are satisfied with adequate margin.

4. Analyze test data to assess residual risk from untested threats. Examples of untested threats include, but are not limited to, high-LET GCRs or EEEE parts in untested electrical configurations.

5. Verify the relevance of test data to flight units.

2.2 Hardness Assurance Design Documentation

The contractor shall prepare and make available to the Acquisition Activity the mission radiation risk analysis that summarizes the environments and box-level performance determined through radiation testing or other radiation hardness assurance techniques. The mission radiation risk analysis shall include verification that the review, analysis and reporting of test results or other radiation hardness assurance techniques demonstrates satisfaction of the mission requirements described in the radiation tolerance program plan.

If radiation testing is carried out as part of the radiation tolerance program plan, then the following documentation shall be included in the mission radiation risk analysis:

1. A detailed radiation test plan that demonstrates that test results will satisfy the mission requirements with adequate margin.

2. A record of execution of the radiation tests, including test anomalies and variances from the test plan.

3. All test reports, including analysis of test results, which demonstrate that all mission requirements are satisfied with adequate margin.

4. Analysis of test results to assess residual risk from untested threats, if any. Examples of untested threats include, but are not limited to, high-LET GCRs or EEEE parts in untested electrical configurations.

5. Verification of the relevance of test results to flight units.

2.3 Preliminary and Critical Design Reviews

PMPCA shall be informed of any design decisions that are made as a result of radiation test results. PMPCA shall ensure that any parts that show a susceptibility to the radiation environment and do not meet the mission specific requirements will be marked as “Obsolete” and updated in the PMPSL.

2.4 Hardness Assurance for Custom Application-Specific Integrated Circuits (ASICs)

If custom application-specific integrated circuits (ASICs) are utilized in the vehicle design, then the contractor shall ensure that the design and construction of custom ASIC devices incorporate the following requirements:

1. Capabilities of circuit designers and manufacturers shall meet all quality and radiation requirements for launch vehicle programs.

2. Design feasibility assessment shall be performed by the contractor during the conceptual design phase.

3. Design requirements for hardness assurance testability shall be incorporated into the design.

4. Radiation critical layout rules and circuit design considerations shall be assessed.

5. Radiation critical procedures and process requirements shall be adhered to during wafer fabrication and assembly.

3. Hardness Assurance Verification

3.1 Hardness Verification Analyses

The contractor shall prepare and submit a mission radiation risk analysis that summarizes the environments and box-level performance determined through radiation testing or other radiation hardness assurance techniques. The Mission Radiation Risk Analysis shall include assessments of the residual risk from untested threats and of the relevance of test results to flight units.

3.2 Radiation Characterization Tests

The contractor shall conduct radiation characterization of all EEEE parts that may be exposed to radiation during the specified mission. The radiation characterization tests shall consist of exposing the test sample to increasing radiation levels until the parametric or the functional failure value for the device has been reached or until the radiation levels exceed the anticipated levels in the mission environment with adequate margin. All failure values shall be based on both a worst case circuit analysis and the applicable device specifications. Use of existing databases or alternate assessment methodologies is acceptable when approved by the PMPCA.

Appendix K. Data Item Descriptions

DELETED

Appendix L. ELV Quality Baseline and Electronic Part Procurement Order of Precedence

1. Purpose and Application

For the purposes of this document the ELV Quality PMP Baseline shall be defined as specified below in each part type category. The order of precedence is the listed order in each category.

1. Semiconductors (transistors and diodes) procured to:

   a. MIL-PRF-19500, Appendix E, Table IV, JANS

   b. Lower-quality-level semiconductors shall be upscreened to meet the MIL-PRF-19500 JANS requirements.

2. Microcircuits procured to:

   a. The detailed specifications of MIL-PRF-38535, Class V

   b. Lower quality level microcircuits shall be upscreened to meet the MIL-PRF-38535 Class V and Y requirements.

3. Hybrids procured to:

   a. The detailed specifications of MIL-PRF-38534, Class K, Appendix C.

   b. Lower-quality-level hybrid microcircuits shall be upscreened to meet the MIL-PRF-38534 Class K and L requirements.

4. Relays procured to:

   a. The custom processing and screening requirements called out in Appendix D, Tables D-1 through D-4

   b. The detailed specifications of MIL-PRF-39016, failure rate level “P” or better, and listed on the applicable specification’s QPL

5. Magnetic devices manufactured, screened, and qualified in accordance with MIL-STD-981, Class S

6. Resistors/thermistors procured to:

   a. MIL-PRF-55342, T-level, U-level or V-level, MIL-PRF-32159, T-level, DSCC Dwgs 04007B, 04008B, 04009B, 94012F, 94013F, 94015H, 94016G, 94017F, 94017F, 94018F, 94019F, 94025G, T-level

   b. The detailed specifications of MIL-PRF-39005, MIL-PRF-39007, MIL-PRF-39009, MIL-PRF-55182, MIL-PRF-55342, MIL-PRF-39017, exponential failure rate “S” or “R” when the “S” version is not listed on the QPL

   c. The detailed specifications of MIL-PRF-23648, MIL-PRF-83401 (“M” level part numbers only) and listed on the applicable QPL

7. Capacitors procured to:

   a. The detailed specifications of MIL-PRF-123, MIL-PRF-49467, MIL-PRF-49470 T level, MIL-PRF-55365 T Level, MIL-PRF-87164, or MIL-PRF-39003/10 Weibull failure rate “C,” and listed on the applicable QPL, DSCC Drawings 06013, 06014, 06015, 06016 for wet slug tantalum capacitors, DSCC Drawings 06019, 06022 for ceramic chip capacitors in high frequency applications.

b. The detailed specification of MIL-PRF-23269, MIL-PRF-55681, MIL-PRF-20, MIL-PRF-39014, MIL-PRF-39006 (H designated parts only), and MIL-PRF-83421, Exponential failure rate “S” or “R” when the “S” version is not listed on the QPL. MIL-PRF-39003 and MIL-PRF-55365, Weibull failure rate “E,” “D,” “C,” or “B” and with surge current option C.

8. Wire and cable constructions listed in Appendix E

9. Connectors manufactured and screened in accordance with MIL-DTL-3655, MIL-C-5015, MIL-DTL-24308, MIL-DTL-26482, MIL-DTL-38999, MIL-PRF-39012, MIL-PRF-55302, MIL-DTL-83723, or MIL-DTL-83733, whichever is applicable

10. Crystal and crystal oscillators manufactured and 100% screened in accordance with MIL-PRF-3098 (crystals), or MIL-PRF-55310 for Class S (oscillators)

11. Fuses manufactured and screened in accordance with MIL-PRF-23419 /12 and /13

12. Filters manufactured and screened in accordance with the Class B requirements of MIL-PRF-28861, with the exception that all piece parts utilized in the filter meet the requirements of the ELV quality PMP baseline

13. Materials and processes listed in the approved Parts, Materials, and Processes Selection List (PMPSL) for unlimited use

SMC Standard Improvement Proposal

INSTRUCTIONS

1. Complete blocks 1 through 7. All blocks must be completed.
2. Send to the Preparing Activity specified in block 8.

NOTE: Do not use this form to request copies of documents, or to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Comments submitted on this form do not constitute a commitment by the Preparing Activity to implement the suggestion; the Preparing Authority will coordinate a review of the comment and provide disposition to the comment submitter specified in Block 6.

SMC STANDARD CHANGE RECOMMENDATION:	**1. Document Number**	**2. Document Date**
	SMC-S-011	31 July 2015

3. Document Title	PARTS, MATERIALS, AND PROCESSES CONTROL PROGRAM FOR EXPENDABLE LAUNCH VEHICLES

4. Nature of Change
(Identify paragraph number; include proposed revision language and supporting data. Attach extra sheets as needed.)

5. Reason for Recommendation

6. Submitter Information

a. Name	**b. Organization**
c. Address	**d. Telephone**
e. E-mail address	**7. Date Submitted**

8. Preparing Activity

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